DOE/NV--953

U.S. DEPARTMENT OF ENERGY

Gasbuggy Site
ENVIRONMENTAL MANAGEMENT
END STATE VISION
Final

Executive Summary

The Environmental Management End State Vision is to be used as the primary tool for communicating the individual site end state to the involved parties (e.g., U.S. Department of Energy [DOE], regulators, public stakeholders, Tribal Nations). The end state document is not a decisional document. If the DOE decides to seek changes to the current compliance agreements, decisions, or statutory/regulatory requirements, those changes will be made in accordance with applicable requirements (DOE/EM, 2003).

Restoration activities have been conducted on the surface of the Gasbuggy Site; however, an investigation of subsurface contamination has not yet been completed. Therefore, the surface and subsurface end states are treated separately within this document.

The Gasbuggy Site is located inside the Carson National Forest, in Rio Arriba County in northwestern New Mexico. The city of Farmington is approximately 55 miles west of the site and is the closest township with a population greater than 40,000. The Gasbuggy Site was the location of a single subsurface nuclear test conducted in December 1967, by the U.S. Atomic Energy Commission. The site surface is currently managed by the U.S. Department of Agriculture, Forest Service (DOE/EM, 2001). The DOE Nevada Site Office (DOE/NSO) plans to complete environmental restoration activities for surface areas at the Gasbuggy Site, and to continue long-term stewardship activities of subsurface contamination.

Corrective action investigations conducted from 2000 to 2002 indicated that there are currently two areas of surface contamination at the site. Results from soil samples collected during these investigations indicated that arsenic, semivolatile organic compounds, and/or total petroleum hydrocarbons were present above screening levels in one or more samples.

The DOE expects to complete surface remediation activities at the site in fiscal year 2004. Upon completion of closure activities for the surface, all New Mexico Environment Department comments on the closure report will have been addressed, and all Voluntary Remediation Program required documentation filed. At that time, the DOE will request a certificate of completion for the surface area at the Gasbuggy Site, and the site surface will be in the end state (NNSA/NSO, 2003).

Based on the historic use of the Gasbuggy Site and characterization conducted at similar sites, contaminants of concern for the subsurface are expected to include radioactive fission products,

plutonium, uranium, and tritium; however, monitoring and modeling have not yet defined the extent of subsurface hazards.

The subsurface contamination will be addressed by implementing an end state approach based on defining a contaminant boundary at the Gasbuggy Site and monitoring subsurface resource development to ensure that gaseous radionuclides do not migrate past the existing restriction boundary. Migration to the existing restriction boundary, both under non-stressed and stressed (production) conditions, is being evaluated. If migration is found to be significant (which may be determined by a risk assessment), then the restriction zone will be enlarged. Drilling and subsurface resource extraction within the contaminant boundary will be prohibited, and resource (natural gas) production may also be limited for some region outside the boundary. This approach will be protective because, though it is not technologically feasible to remediate the contamination associated with an underground nuclear test, the use (withdrawal) of and exposure to contaminated natural gas will be precluded by implementation of institutional controls restricting the drilling of wells within the boundary. Resource development patterns in the area will be monitored to assess whether the boundary remains protective if resource extraction characteristics change through time, and samples of natural gas from nearby wells may be monitored for radionuclides. If radionuclides are ever found in nearby production wells, the radionuclide transport model will be re-evaluated to determine if the drilling restriction area and associated institutional controls need to be changed.

According to the Life-Cycle Baseline Revision 5, the DOE/NSO expects to complete closure of the Gasbuggy Site subsurface in fiscal year 2014. The DOE/NSO assumes that monitoring will be performed for 100 years (2014 to 2114), and will refine existing subsurface intrusion restrictions as necessary, based on the outcome of the investigation and modeling efforts (DOE/EM, 2001). The end state for the subsurface of the Gasbuggy Site will be to continue monitoring and maintenance of institutional controls indefinitely.

The DOE/NSO developed a public participation plan for the Gasbuggy Site Environmental Management End State Vision. The plan provided a draft copy of this document, an information sheet, and a letter soliciting feedback by July 1, 2004, to involved parties and stakeholders. All written comments that were submitted to the DOE/NSO received comment resolution.

Table of Contents

List of Acronyms and Abbreviations

AEC	U.S. Atomic Energy Commission
bgs	Below ground surface
BLM	U.S. Department of the Interior, Bureau of Land Management
COC	Contaminant(s) of concern
CSM	Conceptual site model
DOE	U.S. Department of Energy
DOE/NSO	U.S. Department of Energy, Nevada Site Office
EM	U.S. Department of Energy, Environmental Management Program
EPA	U.S. Environmental Protection Agency
ft	Foot (feet)
FY	Fiscal year
LTHMP	Long-Term Hydrologic Monitoring Program
PAL	Preliminary Action Level
PLO	Public Land Order
ppm	Parts per million
SGZ	Surface ground zero
TMB	1,2,4-trimethylbenzene
TPH-DRO	Total petroleum hydrocarbons, diesel-range organics
TPH-GRO	Total petroleum hydrocarbons, gasoline-range organics
USDA/FS	U.S. Department of Agriculture, Forest Service
VRP	Voluntary Remediation Program

1.0 Introduction

The Environmental Management End State Vision is to be used as the primary tool for communicating the individual site end state to the involved parties (e.g., U.S. Department of Energy [DOE], regulators, public stakeholders, Tribal Nations). The end state document is not a decisional document. If the DOE decides to seek changes to the current compliance agreements, decisions, or statutory/regulatory requirements, those changes will be made in accordance with applicable requirements (DOE/EM, 2003).

The Environmental Management End State Vision juxtaposes land use with remediation requirements, establishing a conceptual completion goal (or end state) that is both realistic and protective of human health and the environment. The purpose of the vision is to identify where and how potentially harmful exposures to hazardous or radioactive contaminants might occur under projected future conditions, and to determine what actions will be necessary to minimize the potential for harm under those conditions. Consistent with the objectives of cleanup, the vision conceptualizes specific end state conditions that will minimize the potential for harm in the future.

The July 2003 DOE Policy 455.1, "Use of Risk-Based End States," requires DOE Environmental Management Program (EM) sites to define and document a risk-based end state vision that is acceptable to regulators and stakeholders, and then to revise clean-up program plans as necessary to achieve that end state in the most efficient manner (DOE, 2003). The policy is a formal mandate for EM sites to implement risk-based corrective action programs as described in numerous DOE and U.S. Environmental Protection Agency (EPA) publications, American Society of Testing and Materials Standard Guides, and National Research Council recommendations.

Environmental corrective action is an application of standard scientific, engineering, and mathematical principles, enabling steady progress in solving even very complex clean-up problems. The complexities of cleanup at a typical EM site are generally similar: multiple contaminants distributed in multiple environmental media, released over long periods of time and over large areas of land. Uncertainties in source(s), nature, extent, transport, and fate of contaminants are very large and can never be absolutely eliminated. Corrective action provides an objective means of managing uncertainties to the degree necessary and sufficient to make defensible decisions about effective clean-up actions.

The end state vision describes clean-up goals that would be protective under planned future uses. Proposed corrective actions based on risk and other factors associated with land use are presented, negotiated, and agreed to by the State of New Mexico and the DOE.

The DOE's risk-based end state initiative is fully consistent with the EPA's recent endorsement of systematic planning, which uses risk-based decision methods to ensure objectivity, defensibility, and cost-effectiveness in corrective action programs (EPA, 2001). The DOE Nevada Site Office (DOE/NSO) will collaborate with its stakeholders to revise the proposed environmental management end state vision, as needed, to define clear goals for completion of its EM-sponsored clean-up work.

The DOE/NSO developed a public participation plan for the Gasbuggy Site End State Vision. The plan provided a draft copy of this document, an information sheet, and a letter soliciting feedback by July 1, 2004, to involved parties and stakeholders. All written comments that were submitted to the DOE/NSO received comment resolution.

Restoration activities have been conducted on the surface of the Gasbuggy Site; however, an investigation of subsurface contamination has not yet been completed. Therefore, the surface and subsurface end states are treated separately within this document.

The Gasbuggy Site covers approximately 640 acres in the Carson National Forest, and lies approximately 55 miles east of Farmington, New Mexico, in Rio Arriba County. The site was the location of a single subsurface nuclear test conducted in December 1967 by the U.S. Atomic Energy Commission (AEC) (predecessor agency to the DOE). The Gasbuggy Site is currently managed by the U.S. Department of Agriculture, Forest Service (USDA/FS) (DOE/EM, 2001).

Previous surface investigations at the Gasbuggy Site included pre-test subsurface geologic and hydrogeologic studies, evaluations of test effectiveness, radiological monitoring, natural gas sampling, site restoration activities, toxicity characterization, a Comprehensive Environmental Response, Compensation, and Liability Act assessment, a cultural resources survey, a floodplains and wetlands survey, a sensitive species survey, and site investigations for corrective actions (NNSA/NV, 2002).

A surface corrective action investigation of the Gasbuggy Site was completed in 2002. Based on the results from this investigation, the recommended corrective action is to remove surface contamination from two locations at the site by excavation and off-site disposal of waste.

Following excavation activities, the site will be clean closed. The DOE intends to close the site surface under the New Mexico Voluntary Remediation Program (VRP). This is scheduled to be completed in fiscal year (FY) 2004 (DOE/EM, 2001).

The *Site Characterization Work Plan for Gasbuggy, New Mexico* (NNSA/NV, 2002) describes the subsurface investigation, with additional technical details available in *Modeling Approach for Evaluating Radionuclide Transport in Nuclear-Stimulated Gas Reservoirs* (Cooper and Chapman, 2001). Upon construction of a dual-phase (liquid and gas) numerical flow and transport model, production stress will be applied to the modeled system to simulate gas development immediately beyond the current drilling restriction. The results will be analyzed, including a risk assessment if indicated, to determine if the current restrictions are sufficiently protective.

From 1972 to 2002, EPNG Well 10-36 was a part of the EPA's annual Long-Term Hydrologic Monitoring Program (LTHMP) (DOE/NV, 1988). Although tritium was detected in this well, the levels were well below the drinking water standards (NNSA/NSO, 2003). Beginning in 1994, a series of casing evaluation tests were conducted on EPNG Well 10-36. The well failed a pressure test in 2002, and was plugged and abandoned in accordance with New Mexico regulations in September 2003 (Stahl, 2003).

The primary current land uses for the Gasbuggy Site and the surrounding Carson National Forest include cattle grazing and recreation (e.g., hunting, hiking, and camping) (DOE/EM, 2001). The DOE/NSO has not completed characterization of the subsurface at the site, but does not plan to remove subsurface contamination in or around the test cavities due to the lack of feasible remediation technology. The DOE will develop subsurface models and use them to define a contaminant boundary and refine the existing subsurface intrusion restrictions, if necessary. The planned approach for the subsurface investigation is to use existing data to support a subsurface transport model (and dose assessment, if necessary) to evaluate whether existing subsurface intrusion restrictions are sufficient for the protection of human health and the environment (NNSA/NV, 2002).

1.1 Organization of the Report

The Gasbuggy Site Environmental Management End State Vision is organized into five sections. Current state and end state maps have been prepared for each section; however, when the current and end states are the same, a single map is presented.

Section 1.0 introduces the site, including a brief discussion of past, present, and future site missions. This section also briefly discusses site hazards, the extent of environmental contamination, past remediation work, and any planned future clean-up work.

Section 2.0 describes the regional context end state. This section examines physical and surface interface and human and ecological land use in the regional context. Maps showing the current state and the end state are also included for each subsection.

Section 3.0 describes the site-specific end state. This section examines physical and surface interface and human and ecological land use for the site and immediately adjacent lands. Legal ownership and demographics are also presented, and each subsection includes maps showing the current state and the end state.

Section 4.0 discusses specific hazards at the site, including the nature of each hazard, potential impacts on human health and the environment, and any hazard mitigation identified. This section includes a current site-wide hazard map in addition to current and end state maps for each specific hazard. A conceptual site model (CSM) is also included in this section. This model shows the current state and the end state for each hazard. The CSM is used to show the known and potential contaminant pathways, potential receptors, and barriers that have been put in place to minimize exposure to contamination.

Section 5.0 provides references used to develop the Gasbuggy Site Environmental Management End State Vision.

Attachment A provides a report table detailing that there are no variances between the end state vision and current remediation plans for this site.

1.2 Site Mission

Planning activities for the Gasbuggy test began at the site in 1965. The site remained active until site restoration activities concluded in 1978 (NNSA/NV, 2002). The site was the location of a single subsurface nuclear test conducted in December 1967, by the AEC. The Gasbuggy test was the first of three joint government/industry experiments conducted under the Plowshare Program to test the effectiveness of nuclear explosives to fracture low-permeability natural gas reservoirs in order to stimulate production (DOE/EM, 2001).

Other than subsurface risk characterization and long-term stewardship, there is no future mission for this site by the DOE/NSO. Upon completion of closure activities for the surface, all New Mexico Environment Department comments on the closure report will have been addressed, and all VRP-required documentation filed. At that time, the DOE/NSO will request a certificate of completion for the surface area at the Gasbuggy Site, and the site surface will be in the end state (NNSA/NSO, 2003).

The DOE/NSO intends to retain long-term stewardship of the subsurface at the Gasbuggy Site due to residual contamination. Based on the historic use of the site and characterizations conducted at similar sites, the contaminants of concern (COCs) for the subsurface are expected to include radioactive fission products, plutonium, uranium, and tritium. Table 1.1 shows the representative source term for the Gasbuggy Site. At present, the hazard extent has not been defined for the subsurface; however, the DOE plans to conduct investigation and modeling activities of subsurface contamination beginning in FY 2007. These activities are expected to be completed in FY 2011, and closure of the subsurface is expected in FY 2014. Existing subsurface intrusion restrictions will be refined as necessary, based on the outcome of the investigation and modeling efforts (DOE/EM, 2001).

Table 1.1 Representative Source Term for the Gasbuggy Site

Mean radionuclide inventory for 76 nuclear tests detonated below or within 328 feet of the water table in Areas 19 and 20 at the Nevada Test Site. Values are decay corrected to January 1, 1994 (Smith, 2001). Unclassified site-specific mass estimates for the Gasbuggy test are substituted where available from Holzer (1970) and Earman et al. (1996).

Radionuclide	Isotope Symbol	Half life ($t_{1/2}$; year)	Estimated Inventory (Ci) [a]
Tritium	H-3	1.23E+01	4.5E+04[b]
Carbon-14	C-14	5.73E+03	7.3E+00
Aluminum-26	Al-26	7.30E+05	1.18E-04
Chlorine-36	Cl-36	3.01E+05	2.82E+00
Argon-39	Ar-39	2.69E+02	2.43E+01
Potassium-40	K-40	1.28E+09	6.17E+00
Calcium-41	Ca-41	1.03E+05	2.16E+01
Nickel-59	Ni-59	7.60E+04	5.25E-01
Nickel-63	Ni-63	1.00E+02	5.54E+01
Krypton-85	Kr-85	1.07E+01	3.5E+02[b]
Strontium-90	Sr-90	2.91E+01	4.8E+03[c]
Zirconium-93	Zr-93	1.50E+06	5.49E-01
Niobium-93m	Nb-93m	1.61E+01	9.99E+01
Niobium-94	Nb-94	2.00E+04	2.28E+00
Technetium-99	Tc-99	2.13E+05	4.04E+00
Paladium-107	Pd-107	6.50E+06	2.07E-02
Cadmium-113m	Cd-113m	1.41E+01	1.53E+01
Tin-121m	Sn-121m	5.50E+01	5.67E+01
Tin-126	Sn-126	1.00E+05	6.47E-01
Iodine-129	I-129	1.57E+07	1.24E-02
Cesium-135	Cs-135	2.30E+06	4.17E-01
Cesium-137	Cs-137	3.02E+01	5.76E+03[c]
Samarium-151	Sm-151	9.00E+01	7.51E+02
Europium-150	Eu-150	3.60E+01	1.46E+01
Europium-152	Eu-152	1.35E+01	4.33E+02
Europium-154	Eu-154	8.59E+00	2.04E+02
Holmium-166m	Hm-166m	1.20E+03	5.89E-01
Thorium-232	Th-232	1.40E+10	7.68E-04
Uranium-232	U-232	7.00E+01	3.36E+00
Uranium-233	U-233	1.59E+05	2.25E+00
Uranium-234	U-234	2.46E+05	1.62E+00
Uranium-235	U-235	7.04E+08	2.18E-02
Uranium-236	U-236	2.34E+07	6.22E-02
Uranium-238	U-238	4.47E+09	2.88E-02
Neptunium-237	Np-237	2.14E+06	4.80E-01
Plutonium-238	Pu-238	8.77E+01	9.42E+01
Plutonium-239	Pu-239	2.41E+04	2.54E+02
Plutonium-240	Pu-240	6.56E+03	8.16E+01
Plutonium-241	Pu-241	1.44E+01	1.18E+03
Plutonium-242	Pu-242	3.75E+05	4.42E-02
Americium-241	Am-241	4.33E+02	6.14E+01
Americium-243	Am-243	7.37E+03	2.36E-03
Curium-244	Cm-244	1.81E+01	3.91E+01

[a]Except where noted, value is from the mean unclassified radionuclide inventory for 76 nuclear tests detonated below or within 328 ft of the water table in Areas 19 and 20 of the Nevada Test Site.
[b]Value is an unclassified estimate for the Gasbuggy test specifically, from Holzer (1970).
[c]Value is an unclassified estimate for the Gasbuggy test specifically, from Earman et al. (1996).

1.3 Status of Clean-up Program

A corrective action investigation of the Gasbuggy Site was performed from August to September 2000, and July to October 2002. Soil samples collected during these efforts were analyzed for total metals, volatile organic compounds, semivolatile organic compounds, total petroleum hydrocarbons (TPH) (diesel-range organics [DRO] and gasoline-range organics [GRO]), and tritium (NNSA/NSO, 2003).

The preliminary field investigation reported that additional analysis of soil samples for tritium was determined to be unnecessary based on the results obtained; however, as a best management practice, tritium was analyzed in several soil samples collected in 2002. Tritium was not detected at concentrations exceeding the minimum detectable level; therefore, tritium does not present a risk to human health or the environment at this site (NNSA/NSO, 2003).

Soil sample results for arsenic, 1,2,4-trimethylbenzene (TMB), TPH-DRO, and TPH-GRO indicated that these constituents were present above screening levels in one or more samples. The arsenic results were determined to be representative of background concentrations found throughout the Gasbuggy Site; therefore, it was determined that arsenic poses no increased risk to human health or the environment (NNSA/NSO, 2003). A preliminary risk assessment for TMB determined that levels found at the site are below concentrations determined to be hazardous to human health. Based on the results from this investigation, the recommended corrective action is to remove surface contamination from two locations at the site by excavation and off-site disposal of waste. Following removal of contaminated soils, the DOE/NSO intends to seek clean closure for the site surface under the New Mexico VRP. Closure will be accomplished by removing soil with TMB and TPH levels that exceed negotiated clean-up levels of 100 parts per million (ppm) (NNSA/NSO, 2003).

One groundwater monitoring well (EPNG Well 10-36) was located on the Gasbuggy Site. From 1972 to 2002, this well was a part of the annual EPA LTHMP (DOE/NV, 1988). Although tritium was detected in the well, the levels were well below the drinking water standards (NNSA/NSO, 2003). The well was plugged and abandoned in September 2002, in accordance with New Mexico regulations (Wycoff, 2003; Lyles et al., 2003), due to concerns about the integrity of the casing.

2.0 Regional Context End State Description

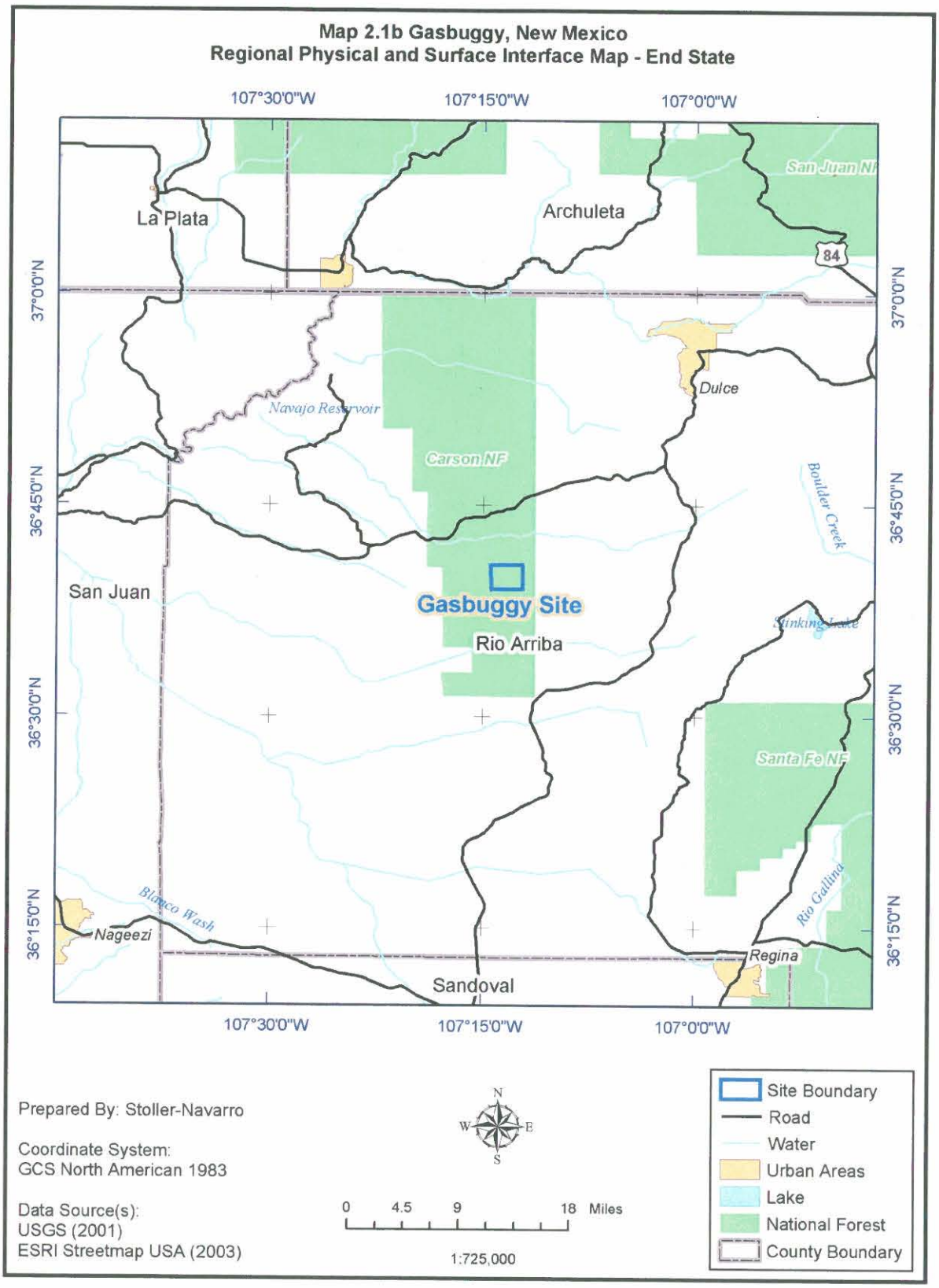
This section examines physical and surface interface and human and ecological land use in the regional context. This section also provides a discussion of current and planned future land use for the region surrounding the Gasbuggy Site.

2.1 Regional Physical and Surface Interface

The Gasbuggy Site is defined as the SW 1/4 section of Section 36, Township 29 north, Range 4 west, and disturbed areas outside these boundaries, which were impacted by DOE/NSO operations (Map 2.1b). The Gasbuggy Site is in the northeast portion of the San Juan Basin, a structural feature of the Colorado Plateau Province covering northwestern New Mexico and southwestern Colorado. The Gasbuggy Site is surrounded by typical canyon and plateau topography of the Colorado Plateau Province. Elevations range from 6,800 to 7,500 feet (ft) around the site and from 7,000 to 7,300 ft at the site (DOE/NV, 1988). The natural contour of the site slopes northeast into Leandro Canyon, a tributary of the ephemeral La Jara Creek.

The nuclear device used for the Gasbuggy test was detonated in the San Juan Basin, a large structural basin composed of more than 11,000 ft of Paleozoic and Tertiary sedimentary rocks. The detonation occurred in the Lewis Shale Formation, at a depth of 4,240 ft below ground surface (bgs). The test was designed to fracture the Pictured Cliffs Formation, a gas reservoir directly overlying the Lewis Shale. The Pictured Cliffs Formation is one of the San Juan Basin's major gas reservoirs; however, in the part of the basin where the Gasbuggy test was conducted, the formation is a low-productivity, sparsely developed reservoir approximately 300 ft thick.

Below the Pictured Cliffs Formation is the Lewis Formation, which is comprised of over 1,500 ft of shale. Overlying the Pictured Cliffs Formation is the 100-ft thick Fruitland Formation, comprised of sandstone, shale, and siltstone, which are overlain by the Kirtland Shale. Above these formations is the Ojo Alamo Sandstone, the only water-bearing unit of concern to the nuclear test. The Ojo Alamo is a fine- to medium-grained, clayey sandstone containing minor shale beds. The bottom of the Ojo Alamo is approximately 600 ft above the detonation point. The top of the Ojo Alamo is approximately 3,465 ft bgs, and the potentiometric surface is approximately 985 ft bgs. The recharge area for the Ojo Alamo is probably in the southeastern portion of the basin, with flow westward or northwestward toward the San Juan River. The Nacimiento and San Jose formations top out the section. Figure 2.1 shows a geologic cross section of the site.


Map 2.1b Gasbuggy, New Mexico
Regional Physical and Surface Interface Map - End State
107°30'0"W
107°15'0"W
107°0'0"W
37°0'0"N
36°45'0"N
36°30'0"N
36°15'0"N
La Plata
Archuleta
San Juan NF
84
Dulce
Navajo Reservoir
Carson NF
Boulder Creek
San Juan
Gasbuggy Site
Rio Arriba
Stinking Lake
Santa Fe NF
Rio Gallina
Blanco Wash
Nageezi
Regina
Sandoval
Prepared By: Stoller-Navarro
Coordinate System:
GCS North American 1983
Data Source(s):
USGS (2001)
ESRI Streetmap USA (2003)
N
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0 4.5 9 18 Miles
1:725,000
Site Boundary
Road
Water
Urban Areas
Lake
National Forest
County Boundary

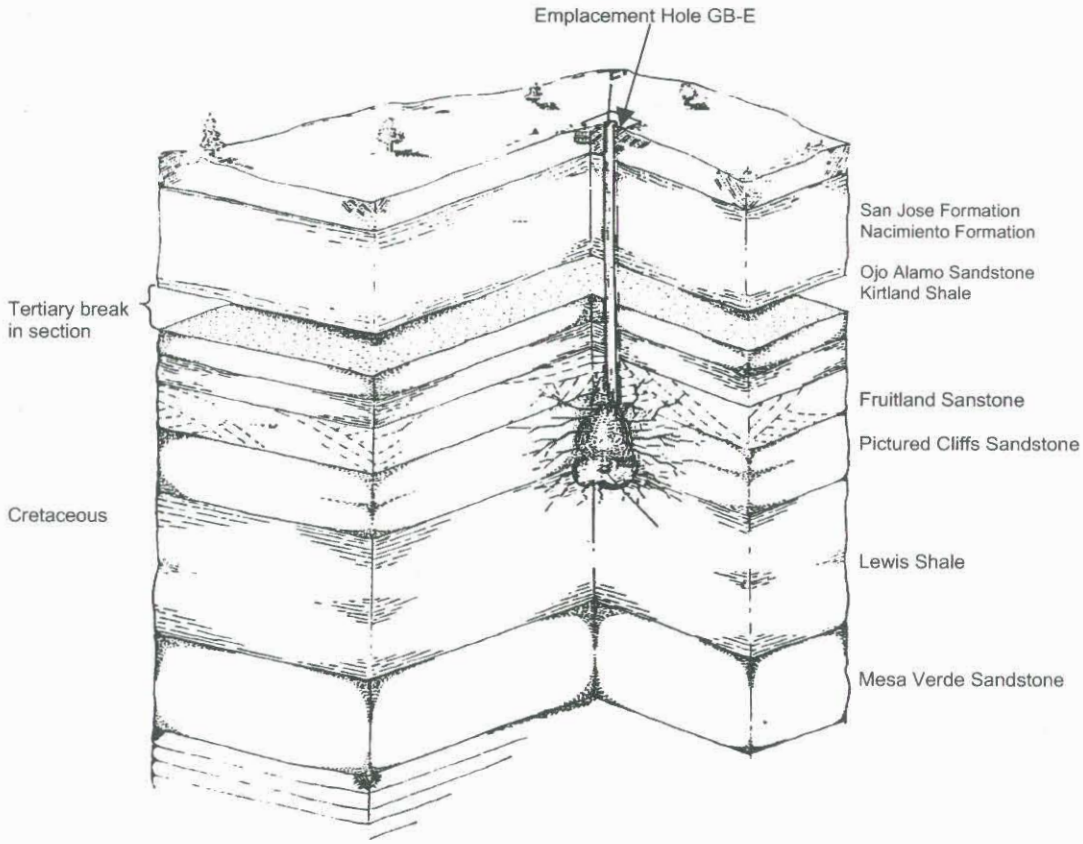


Figure 2.1

Generalized Geologic Cross Section at the Gasbuggy Emplacement Hole

2.2 Human and Ecological Land Use

The primary current land uses for the Gasbuggy Site surface and the surrounding Carson National Forest include cattle grazing and recreation (e.g., hunting, hiking, and camping). Future land use for the site and surrounding area is expected to remain the same; however, the USDA/FS will determine the future use of the surface area. Future roles and responsibilities of the DOE, landowners, and other federal and state agencies are documented in Table 2.1 (Johnston, 2003b).

Table 2.1
DOE/NSO Land Status

Landlord	Surface Steward	Subsurface Steward	Withdrawal Order/Law	Specific Restriction Record	Oil/Gas Owner and Leases	Water Well Permits	Mineral Rights	Grazing Rights
DOE (USDA/FS)	USDA/FS BLM	**Current:** DOE/NSO and BLM **Future:** DOE/Office of Legacy Management	**Surface:** PLO 4232 **Subsurface:** Unknown	On-site plaque	BLM USDA/FS Known leases	DOE/NSO		USDA/FS Issued to Private Users

The Jicarilla Apache Indian Nation lies one mile east of the Gasbuggy Site. The Nation has a current population of approximately 2,755 (U.S. Census Bureau, 2000). The Jicarilla Nation's land use is consistent with the Carson National Forest, with recreation, livestock grazing, and resource development being the primary uses (Map 2.2b). The DOE currently has access rights to, but no maintenance responsibilities for, Road J10 on the Jicarilla Reservation.

The Gasbuggy Site lies within the Cold Temperate climatic zone. Three basic vegetation communities (i.e., forest, scrubland, and grassland) are represented at the site. The forest community is classified as Rocky Mountain Montane Conifer Forest, which is dominated by Ponderosa Pine. This community is typically found along the steeper slopes of the site, forming a band around the drainage areas. The scrubland community is Great Basin Montane Scrub and is found along hilltops, above the forest. Although classified as a scrubland, this community may support Ponderosa and Piñon Pines. The grassland community is further subdivided into two distinct series, the Great Basin Shrub-Grassland, Sagebrush Grass Series, and the Great Basin Shrub-Grassland, Wheatgrass Series (TRC, 2000a).

A sensitive species survey was conducted at the Gasbuggy Site in 2000 (TRC, 2000a). The survey concluded that no effect would occur to federal or state threatened species, endangered species, proposed candidate species, or species of concern as a result of environmental restoration activities taking place at the Gasbuggy Site (TRC, 2000a).

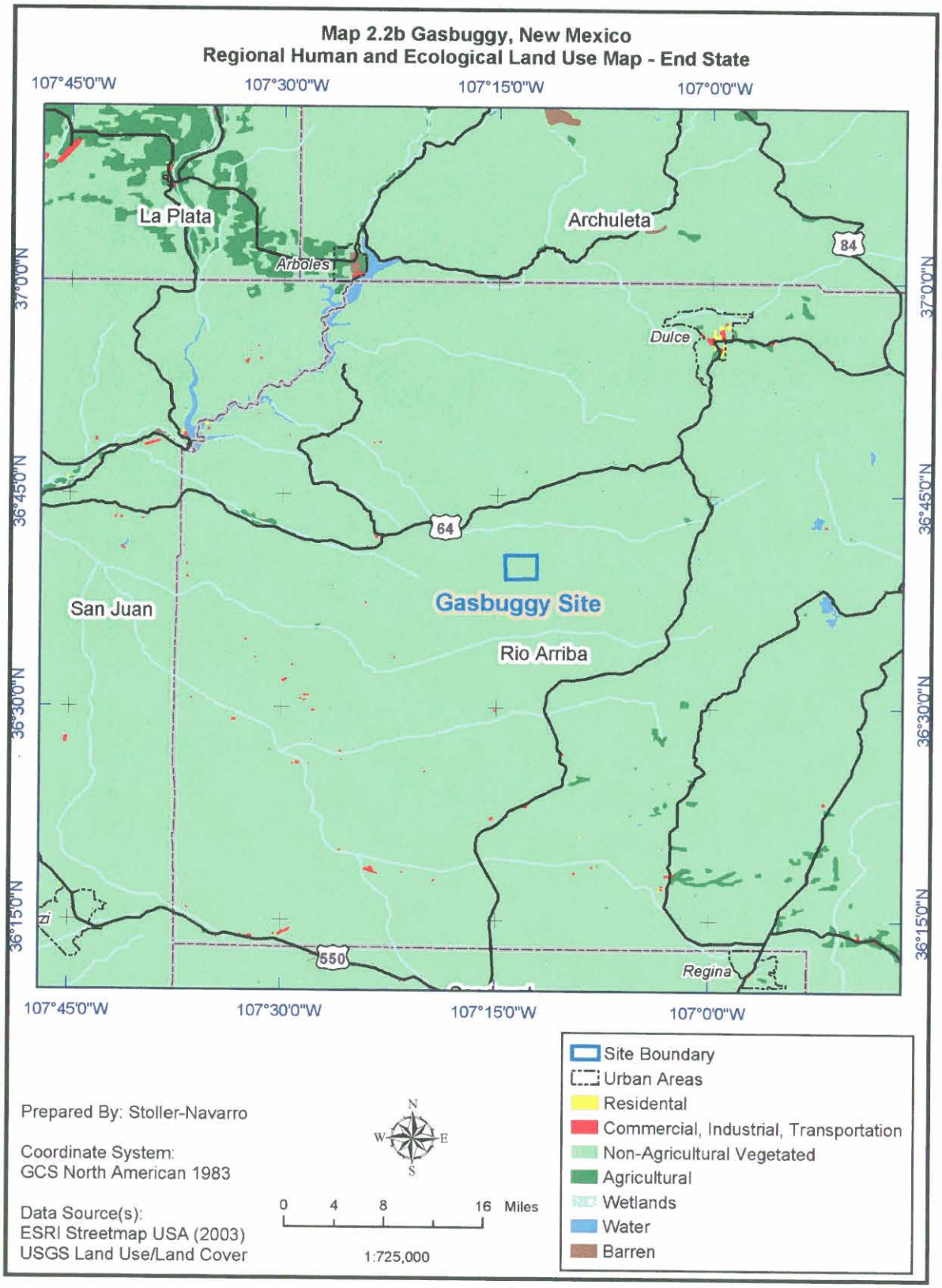
According to a cultural resources survey conducted at the site in 2000, a total of seven recorded historical sites and seven isolated occurrences have been identified on or close to the Gasbuggy Site. Several sites have been recommended as eligible for inclusion into the National Register of

Historic Places (TRC, 2000b). The survey recommends cultural resource monitoring for ground-disturbing environmental investigations and remediation activities (TRC, 2000b).

A floodplains and wetlands survey was conducted at the Gasbuggy Site in 1993. The survey concluded that two man-made cattle tanks constructed close to the site are considered to be wetlands. In addition, the associated drainage channels upstream of the berm, the area upstream of the elevated roads, and the center of the channel are considered floodplain areas (DOE/NV, 1993). The report also recommended that the following considerations should be made for the prevention of flood damage and protection of the floodplains and wetlands located at the Gasbuggy Site (DOE/NV, 1993):

- Cattle tanks should not be damaged or altered during environmental investigations or remedial activities.
- Any activity susceptible to flood damage should not be conducted near the floodplain areas.
- Actions should be taken to prevent excessive discharge of sediments into the drainages of Leandro Canyon.

Future land use for the area around the Gasbuggy Site is expected to be consistent with current use, which includes grazing, oil and gas development, and public recreation such as hiking, skiing, camping, and hunting. Planned remediation of the surface for TPH and TMB is consistent with future land use, and no surface land use restrictions are expected following the remediation; however, subsurface restrictions will remain in place for the foreseeable future (Johnston, 2003a).


Map 2.2b Gasbuggy, New Mexico
Regional Human and Ecological Land Use Map - End State
107°45'0"W
107°30'0"W
107°15'0"W
107°0'0"W
37°0'0"N
36°45'0"N
36°30'0"N
36°15'0"N
La Plata
Archuleta
Arboles
Dulce
84
64
Gasbuggy Site
San Juan
Rio Arriba
550
Regina
Site Boundary
Urban Areas
Residental
Commercial, Industrial, Transportation
Non-Agricultural Vegetated
Agricultural
Wetlands
Water
Barren
Prepared By: Stoller-Navarro
Coordinate System:
GCS North American 1983
Data Source(s):
ESRI Streetmap USA (2003)
USGS Land Use/Land Cover
N
W
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S
0 4 8 16 Miles
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3.0 Site-Specific End State Description

This section examines physical and surface interface and human and ecological land use in the site-specific context. This section also provides a discussion of current and planned future land use for the site, legal ownership of the site and immediately adjacent lands, and demographics for the area.

3.1 Site Physical and Surface Interface

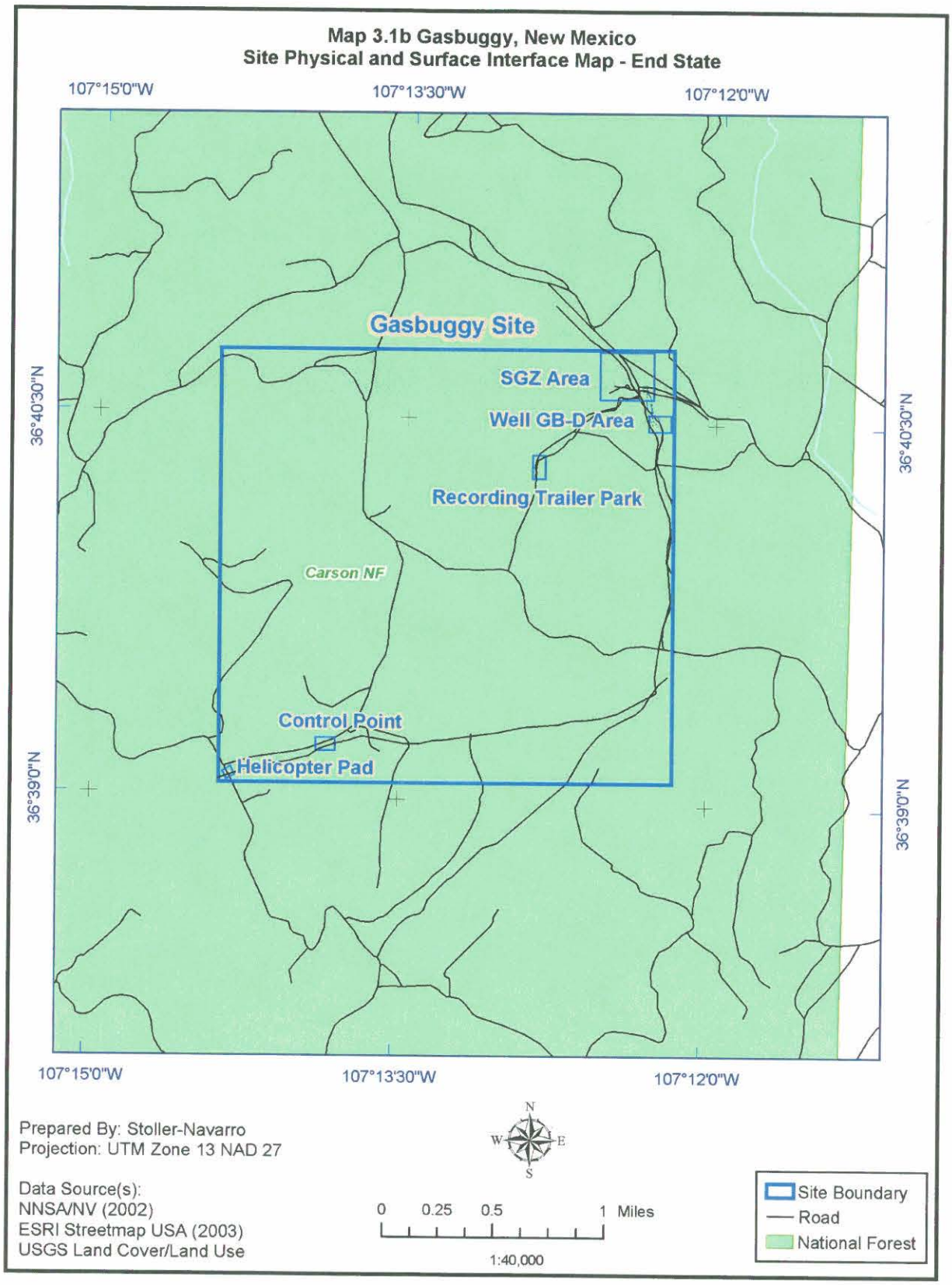
The Gasbuggy Site originally consisted of five operational areas (Map3.1b):

- Surface Ground Zero (SGZ)
- Well GB-D Area
- Recording Trailer Park
- Control Point
- Helicopter Pad

Of these five areas, surface investigations have shown that only the SGZ and the Well GB-D areas contain COCs that will require corrective actions (NNSA/NSO, 2003). The hazards found in these areas are discussed in Section 4.0 of this report.

3.2 Human and Ecological Land Use

There are currently no residences or other habitable structures on the Gasbuggy Site. The site is withdrawn to the AEC under Public Land Order (PLO) 4232, as noted in the *Federal Register*, Vol. 32, No. 124, dated June 28, 1967 (*Federal Register*, 1967). The withdrawal allows the use of the national forest lands under public land laws as long as the activities do not interfere with the AEC's intended project. Jurisdiction over the national forest lands remains with the Secretary of Agriculture for purposes other than those associated with the Gasbuggy test (Johnston, 2003a).


Map 3.1b Gasbuggy, New Mexico
Site Physical and Surface Interface Map - End State
107°15'0"W
107°13'30"W
107°12'0"W
36°40'30"N
36°39'0"N
Gasbuggy Site
SGZ Area
Well GB-D Area
Recording Trailer Park
Carson NF
Control Point
Helicopter Pad
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)
ESRI Streetmap USA (2003)
USGS Land Cover/Land Use
N
W
E
S
0 0.25 0.5 1 Miles
1:40,000
Site Boundary
Road
National Forest

Subsurface use restrictions in the vicinity of the Gasbuggy Site will remain in place in perpetuity. These restrictions, shown on Map 3.2b, are described on the permanent monument located at SGZ on the site. The restrictions are as follows:

> "No excavation, drilling, and/or removal of subsurface materials to a true vertical depth of 1,500 feet is permitted within a radius of 100 feet of this surface location, nor any similar excavation, drilling, and/or removal of subsurface materials between the true vertical depths of 1,500 feet and 4,500 feet is permitted within a 600 foot radius of this surface location in the SE quarter of the SW quarter of Section 36, T 29 N, R 4 W, New Mexico Principal Meridian, Rio Arriba County, New Mexico, without U.S. Government permission" (Johnston, 2003a).

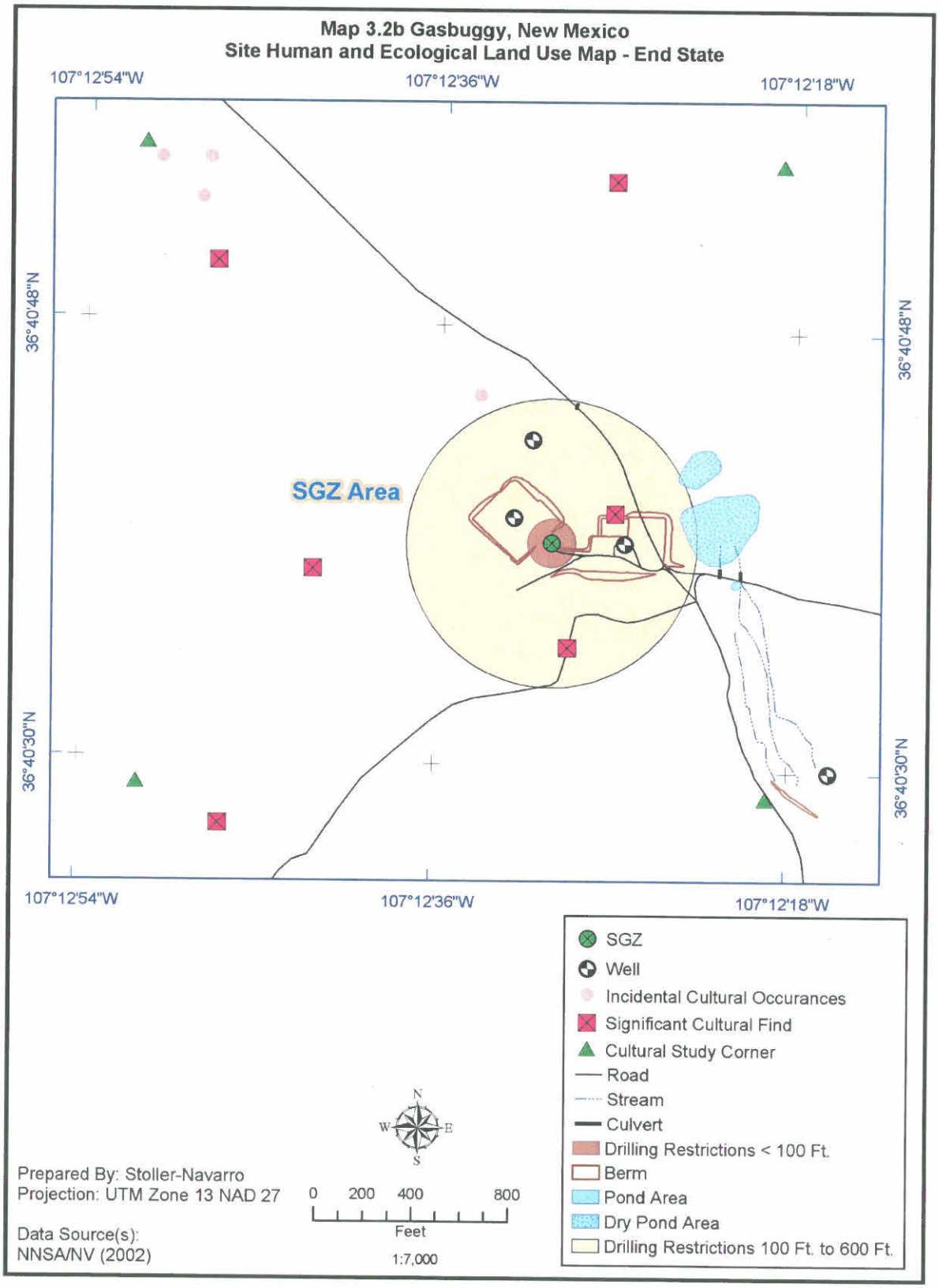
Current land use designations (recreational and grazing) and subsurface intrusion restrictions will continue into the foreseeable future and it is anticipated that this land use will be the end state.

Subsurface contamination is being addressed by implementing an end state approach based on defining a contaminant boundary at the Gasbuggy Site, and monitoring subsurface resource development to ensure that gaseous radionuclides do not migrate past the existing restriction boundary. Migration to the existing restriction boundary, both under non-stressed and stressed (production) conditions, is being evaluated. If migration is found to be significant (which may be determined by a risk assessment), then the restriction zone will be enlarged. Drilling and subsurface resource extraction within the contaminant boundary will be prohibited, and resource (natural gas) production may also be limited for some region outside the boundary. This will be protective because, though it is not technologically feasible to remediate the contamination associated with an underground nuclear test, the use (withdrawal) of and exposure to contaminated natural gas will be precluded by implementation of institutional controls restricting the drilling of wells within the boundary. Resource development patterns in the area will be monitored to assess whether the boundary remains protective if resource extraction characteristics change through time, and samples of natural gas from nearby wells may be monitored for radionuclides. If radionuclides are ever found in nearby production wells, the dual-phase radionuclide model will be re-evaluated to determine if the drilling restriction area and associated institutional control need to be changed.

The DOE/NSO has not yet fully characterized the subsurface contamination, and long-term stewardship activities have not been finalized (DOE/EM, 2001). The DOE/NSO does not plan to remove subsurface contamination in or around the test cavities due to the lack of feasible

remediation technology. Post-closure monitoring will be conducted as agreed upon in the site closure reports for the subsurface (NNSA/NV, 2002).

The DOE/NSO developed a public participation plan for the Gasbuggy Site Environmental Management End State Vision. The plan provided a draft copy of this document, an information sheet, and a letter soliciting feedback by July 1, 2004, to involved parties and stakeholders. All written comments that were submitted to the DOE/NSO received comment resolution.


Map 3.2b Gasbuggy, New Mexico
Site Human and Ecological Land Use Map - End State
107°12'54"W
107°12'36"W
107°12'18"W
36°40'48"N
36°40'30"N
SGZ Area
SGZ
Well
Incidental Cultural Occurances
Significant Cultural Find
Cultural Study Corner
Road
Stream
Culvert
Drilling Restrictions < 100 Ft.
Berm
Pond Area
Dry Pond Area
Drilling Restrictions 100 Ft. to 600 Ft.
N
W
E
S
0
200
400
800
Feet
1:7,000
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)

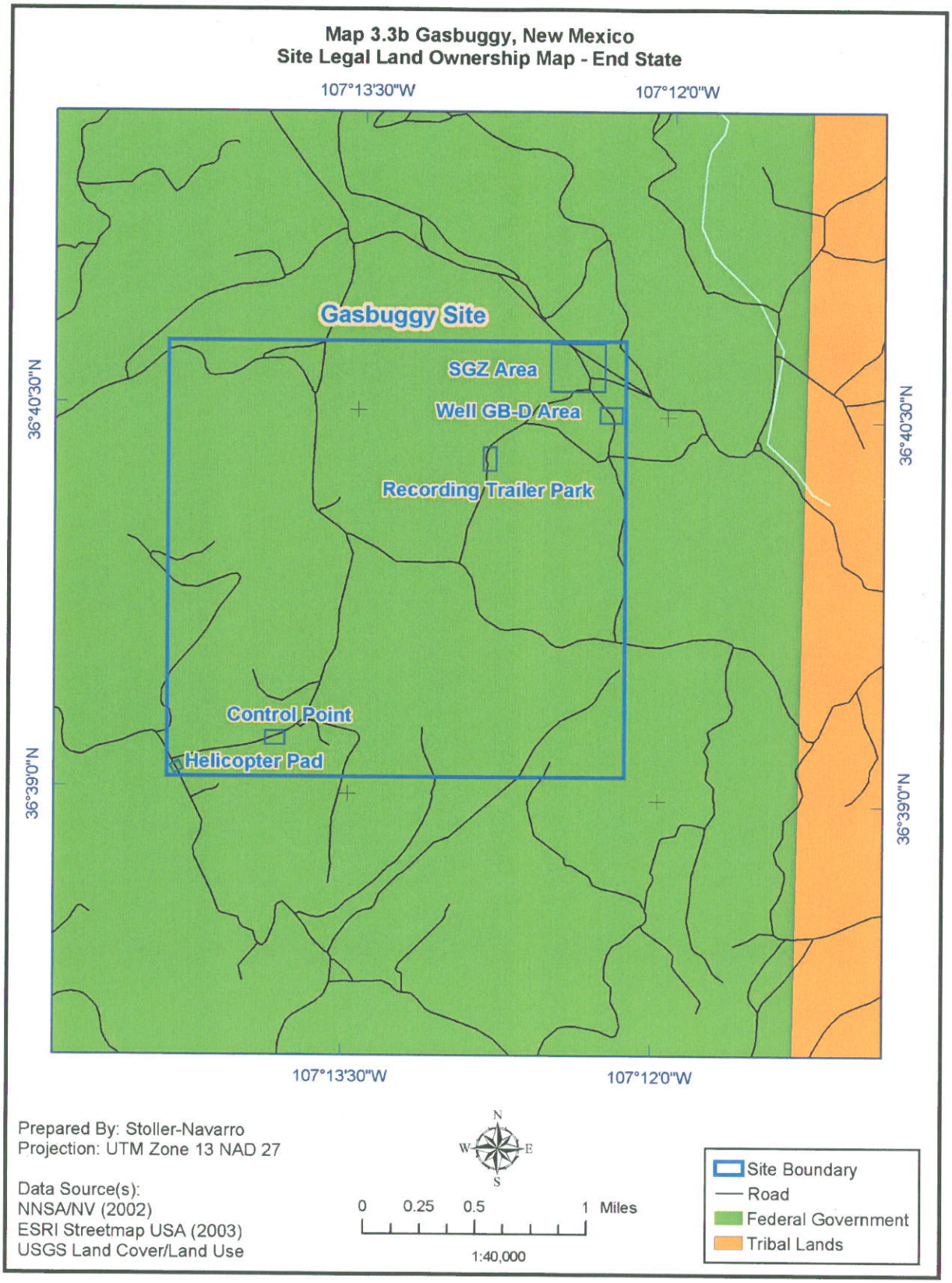
3.3 Site Context Legal Ownership

The Gasbuggy Site is withdrawn under PLO 4232, as noted in the *Federal Register*, Vol. 32, No. 124, dated June 28, 1967 (*Federal Register*, 1967). According to the PLO, the land is withdrawn to the AEC, but the withdrawal "...does not alter the applicability of those public land laws governing the use of the national forest lands under lease, license, or permit, or governing the disposal of their mineral or vegetative resources other than under the mining and mineral leasing laws," as long as the activities do not interfere with the project. The PLO indicates that the jurisdiction over the national forest lands remains with the Secretary of Agriculture for purposes other than those associated with the Gasbuggy test (Map 3.3b) (*Federal Register*, 1967; Johnston, 2003a).

Terms and conditions for the use of the land are governed by a Memorandum of Understanding between Region 3 of the USDA/FS and the AEC, dated August 16, 1967 (DOE/EM, 2001). Conduct of the test logistics, equipment and property use, drilling, and test preparation were under contract between the AEC, the U.S. Department of the Interior, and the El Paso Natural Gas Company (Contract No. AT [04-3]-711) (Johnston, 2003a).

Existing and active gas leases completely surround the Gasbuggy Site but the U.S. Department of the Interior, Bureau of Land Management (BLM) acknowledges the land constituting the Gasbuggy Site as withdrawn to the AEC (DOE) (Johnston, 2003a). Section 36 is not patented land; therefore, the BLM would control oil and gas well permits in the withdrawn land if any applications were filed, subject to approval by the USDA/FS. The DOE bought Well #10-36 from the El Paso Natural Gas Company in September 1978 (Taft, 1978). There are oil and gas wells in the vicinity of the Gasbuggy Site; however, there is no known monitoring for radioactivity in any of these wells (DOE/EM, 2001).

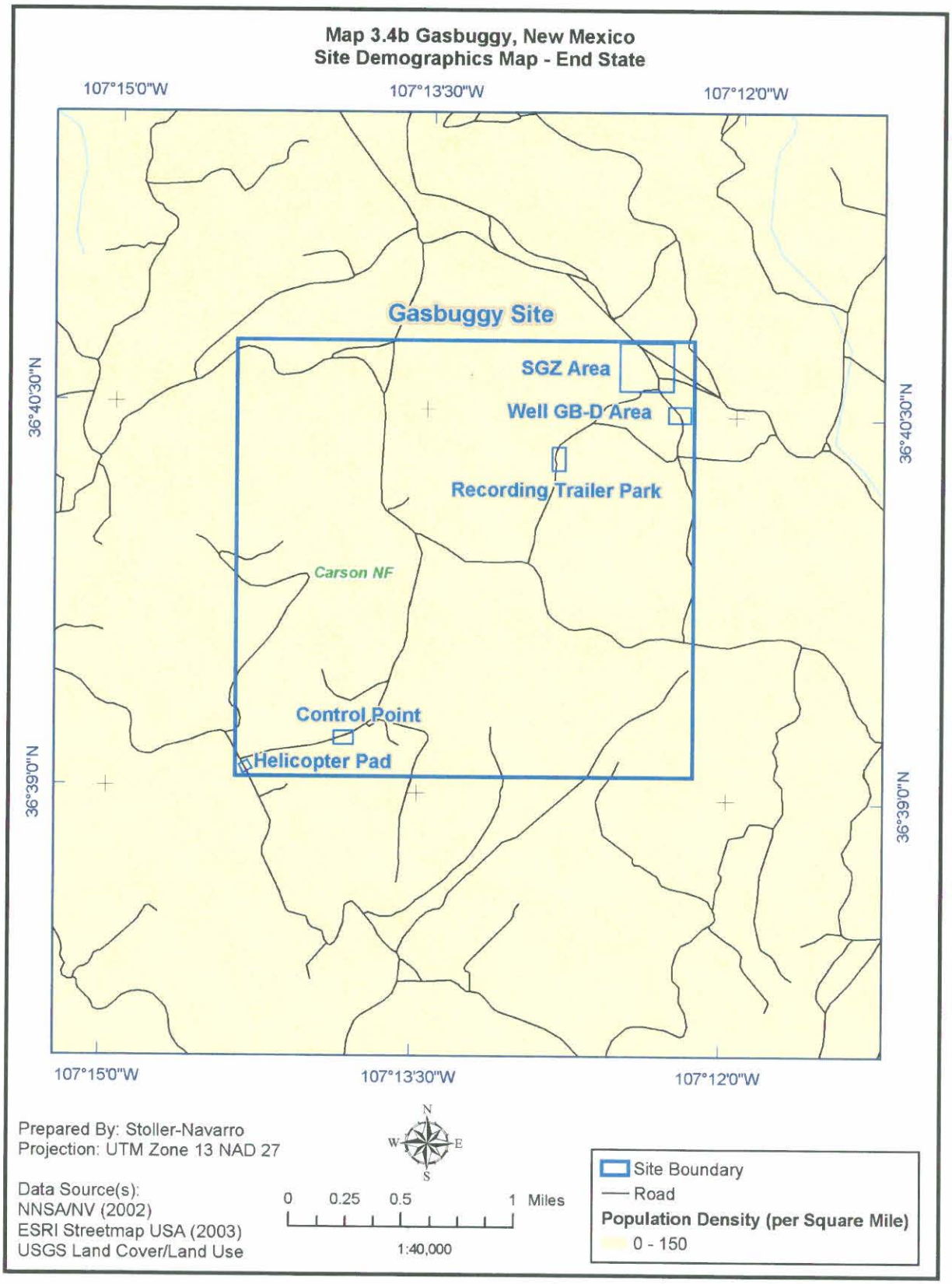
At the end of May 1983, the DOE issued a Notice of Intent to relinquish withdrawn land under PLO 4232. The notice indicated that the DOE no longer needed the land and that it should be returned to national forest use. The notice included terms and conditions to protect the public's interest, including drilling restrictions. In September 1983, the USDA/FS responded with a nonconcurrence letter (BLM file #SF 079761) to the proposed withdrawal relinquishment. The Master Title Plat shows that Section 36 is still withdrawn under PLO 4232 to the DOE (*Federal Register*, 1967; Johnston, 2003a); however, the USDA/FS has agreed with the current surface corrective action and has granted permission to enter the site into the VRP with the ultimate result being a return of the land to the USDA/FS.


Map 3.3b Gasbuggy, New Mexico
Site Legal Land Ownership Map - End State
107°13'30"W
107°12'0"W
36°40'30"N
36°39'0"N
Gasbuggy Site
SGZ Area
Well GB-D Area
Recording Trailer Park
Control Point
Helicopter Pad
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)
ESRI Streetmap USA (2003)
USGS Land Cover/Land Use
N
W
E
S
0 0.25 0.5 1 Miles
1:40,000
Site Boundary
Road
Federal Government
Tribal Lands

3.4 Site Context Demographics

According to the 2000 census, the population of Rio Arriba County is 41,190 (U.S. Census Bureau, 2000). Approximately 5.8 percent of the total housing available in the county is used for seasonal, recreational, or occasional usage. The Jicarilla Apache Indian Nation lies approximately one mile east of the site. The Nation has a current population of approximately 2,755 (U.S. Census Bureau, 2000). It is not anticipated that the human population near the Gasbuggy Site will increase in any significant way in the foreseeable future (Map 3.4b).

The Gasbuggy Site and surrounding land are currently used for recreation, livestock grazing, and resource development as associated with the Carson National Forest. The Gasbuggy Site is surrounded by oil and gas leases. There are no oil or gas wells at the site. Upon surface closure of the site, the end state is expected to be equivalent to the current land use designations, and subsurface intrusion restrictions will continue into the foreseeable future (DOE/EM, 2001). However, the DOE/NSO has not fully characterized the contamination, and long-term stewardship activities have not yet been finalized. Therefore, long-term stewardship activities may change, depending on the final agreements with the State of New Mexico and regulators. The DOE/NSO will reevaluate and modify the subsurface restrictions, as appropriate, as part of the assessment and/or corrective action activities (DOE/EM, 2001).


Map 3.4b Gasbuggy, New Mexico
Site Demographics Map - End State
107°15'0"W
107°13'30"W
107°12'0"W
36°40'30"N
36°39'0"N
Gasbuggy Site
SGZ Area
Well GB-D Area
Recording Trailer Park
Carson NF
Control Point
Helicopter Pad
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)
ESRI Streetmap USA (2003)
USGS Land Cover/Land Use
N
W
E
S
0 0.25 0.5 1 Miles
1:40,000
Site Boundary
Road
Population Density (per Square Mile)
0 - 150

4.0 Hazard-Specific Discussion

Historical data indicates that five areas at the Gasbuggy Site were found to contain COCs:

- Surface Ground Zero
- Well GB-D Area
- Recording Trailer Park
- Control Point
- Helicopter Pad

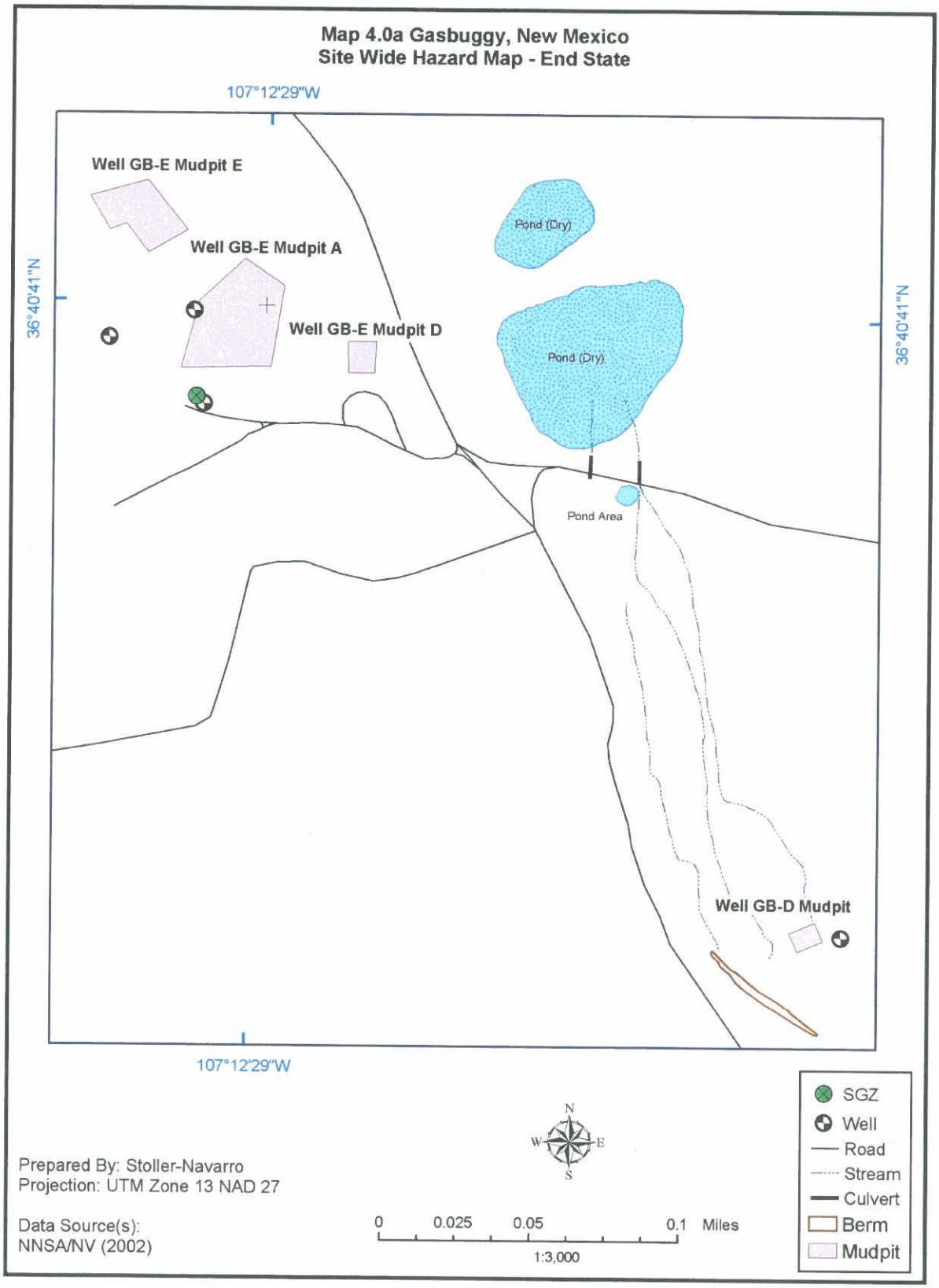
Based on site investigations as documented in *Surface Corrective Action Investigation Report with Surface Corrective Action Plan for the Gasbuggy Site, New Mexico,* it has been determined that only two sites (SGZ and the Well GB-D area) contain surface contamination that will require corrective actions (NNSA/NSO, 2003). Table 4.0 summarizes the hazards and risks associated with the site (DOE/NV, 2000). The areas requiring corrective action are shown on Map 4.0a. Surface corrective actions are scheduled for completion in FY 2004 (DOE/EM, 2001). Map 4.0b shows the end state for the remaining subsurface site hazard after corrective actions for the surface have been completed.

Subsurface characterization has not yet been performed at this site. Based on the historic use of the site and characterization conducted at similar sites, the COCs for the subsurface are expected to include radioactive fission products, plutonium, uranium, and tritium, with the gaseous radionuclides (tritium, carbon-14, and krypton-85) being the most mobile in the environment. At the present time, the hazard extent has not been defined. The DOE/NSO will continue to investigate and model subsurface contamination. Subsurface closure is expected to be completed in FY 2014 (DOE/EM, 2001).

The following sections describe, in detail, the current state and expected end state for the Gasbuggy Site. A CSM for the end state of the site is provided in Figure 4.0. The CSM illustrates the relationship between the identified potential sources of contamination, the mechanisms for release and migration away from the potential source, the pathways the contamination would follow once released, the exposure routes by which potential contamination would affect receptors, and the receptors that would be impacted by potential contamination. Only areas that will continue to act as sources following surface remediation are included in the CSM.

Table 4.0
Gasbuggy Site Hazards and Risks

Material Category	Nature of Hazard	Nature of Potential Risk	Status of Current Management	Planned Risk Reduction Control	Anticipated Risk Reduction Progress	End-State Disposition and Risk
Deep (>3,000 ft bgs) natural gas, groundwater, and test cavity	Groundwater and natural gas in the immediate vicinity of the test cavity are contaminated with radionuclides (tritium and mixed fission products). Migratory potential of the contaminants via natural gas from the test cavities will be modeled.	Migratory potential of radionuclides in natural gas and groundwater is minimal. Existing monitoring data from surrounding wells have not indicated radionuclide contamination. If contaminant migration is verified, the most probable exposure scenarios would be via inhalation of, ingestion of, and dermal contact with natural gas.	Site subsurface characterization, risk analysis, and natural gas modeling activities are ongoing. Site subsurface access is restricted.	Subsurface restrictions and institutional controls are in place and maintained. The subsurface risk-based compliance boundary will be refined based on subsurface modeling results. A refined long-term monitoring program will be implemented, if required and if technically feasible.	Currently, there is no feasible or cost effective corrective action technology to address test cavities and associated subsurface contamination that will prevent risk.	Subsurface restrictions and institutional controls will be maintained and long-term hydrologic monitoring will be implemented, based on the risk assessment and natural gas modeling results.
Surface Soil / Mud pits	Site decommissioning records and characterization indicate that all radioactive material was either disposed of in the test cavity or removed from the site leaving no surface radiological contamination. Site characterization is complete identifying mud pit areas containing TPH concentrations above negotiated action levels.	If residual contamination is discovered, the potential exposure pathway would be inhalation, incidental ingestion, and dermal contact.	Site remediation is planned to remove all surface contaminants and achieve clean closure status.	Remediation activities and confirmatory sampling will be performed to achieve clean closure of the surface and mud pits.	Remediation activities are scheduled for completion in FY 2004.	The anticipated future end state is clean closure and will allow for unrestricted surface use.


Map 4.0a Gasbuggy, New Mexico
Site Wide Hazard Map - End State
107°12'29"W
36°40'41"N
Well GB-E Mudpit E
Well GB-E Mudpit A
Well GB-E Mudpit D
Pond (Dry)
Pond (Dry)
Pond Area
Well GB-D Mudpit
107°12'29"W
36°40'41"N
N
W
E
S
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)
0 0.025 0.05 0.1 Miles
1:3,000
SGZ
Well
Road
Stream
Culvert
Berm
Mudpit

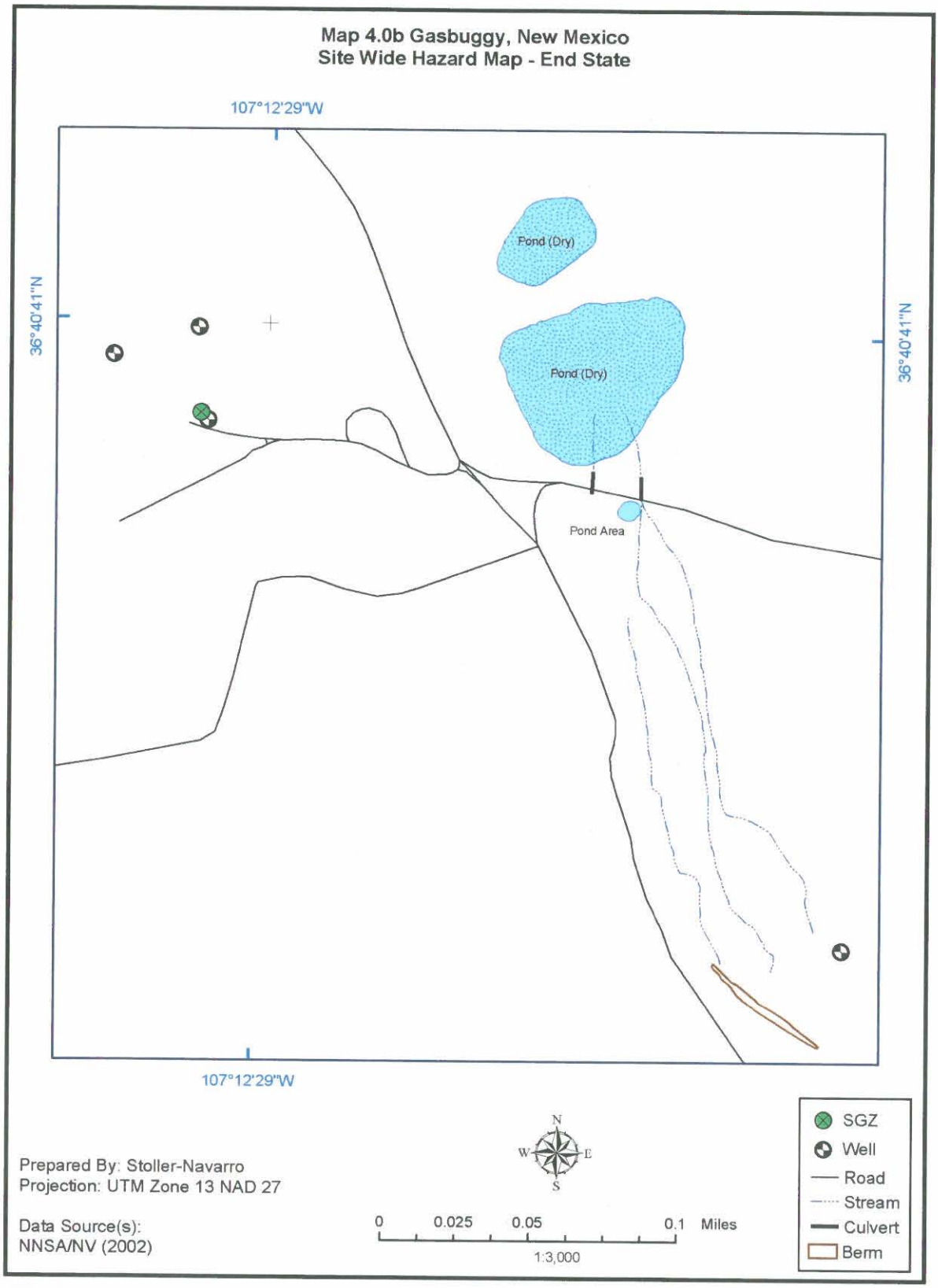
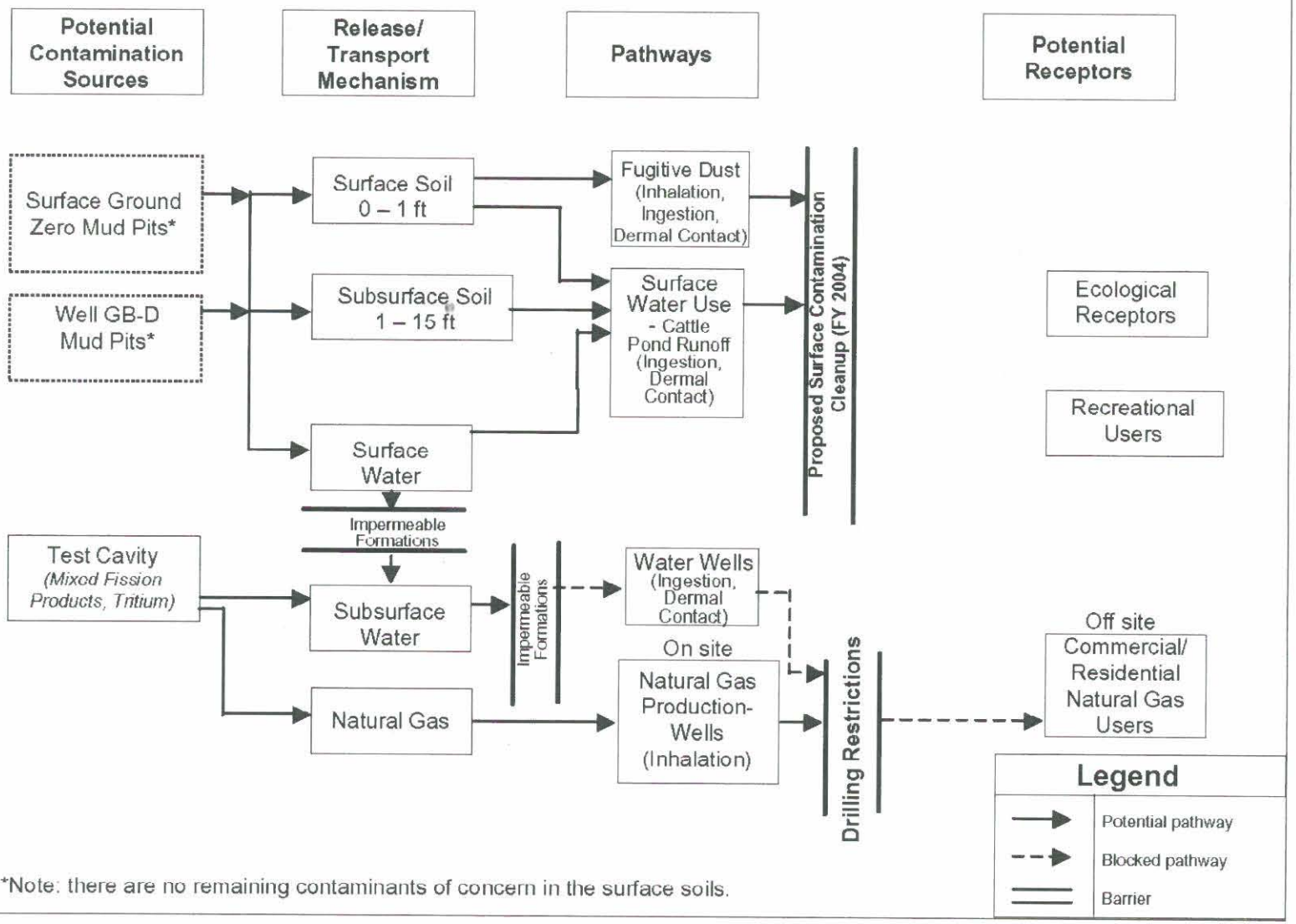

Map 4.0b Gasbuggy, New Mexico
Site Wide Hazard Map - End State
107°12'29"W
36°40'41"N
Pond (Dry)
Pond (Dry)
Pond Area
107°12'29"W
36°40'41"N
N
W
E
S
0
0.025
0.05
0.1 Miles
1:3,000
SGZ
Well
Road
Stream
Culvert
Berm
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)

Figure 4.0 - Gasbuggy Site Conceptual Site Model - Current State and End State



*Note: there are no remaining contaminants of concern in the surface soils.

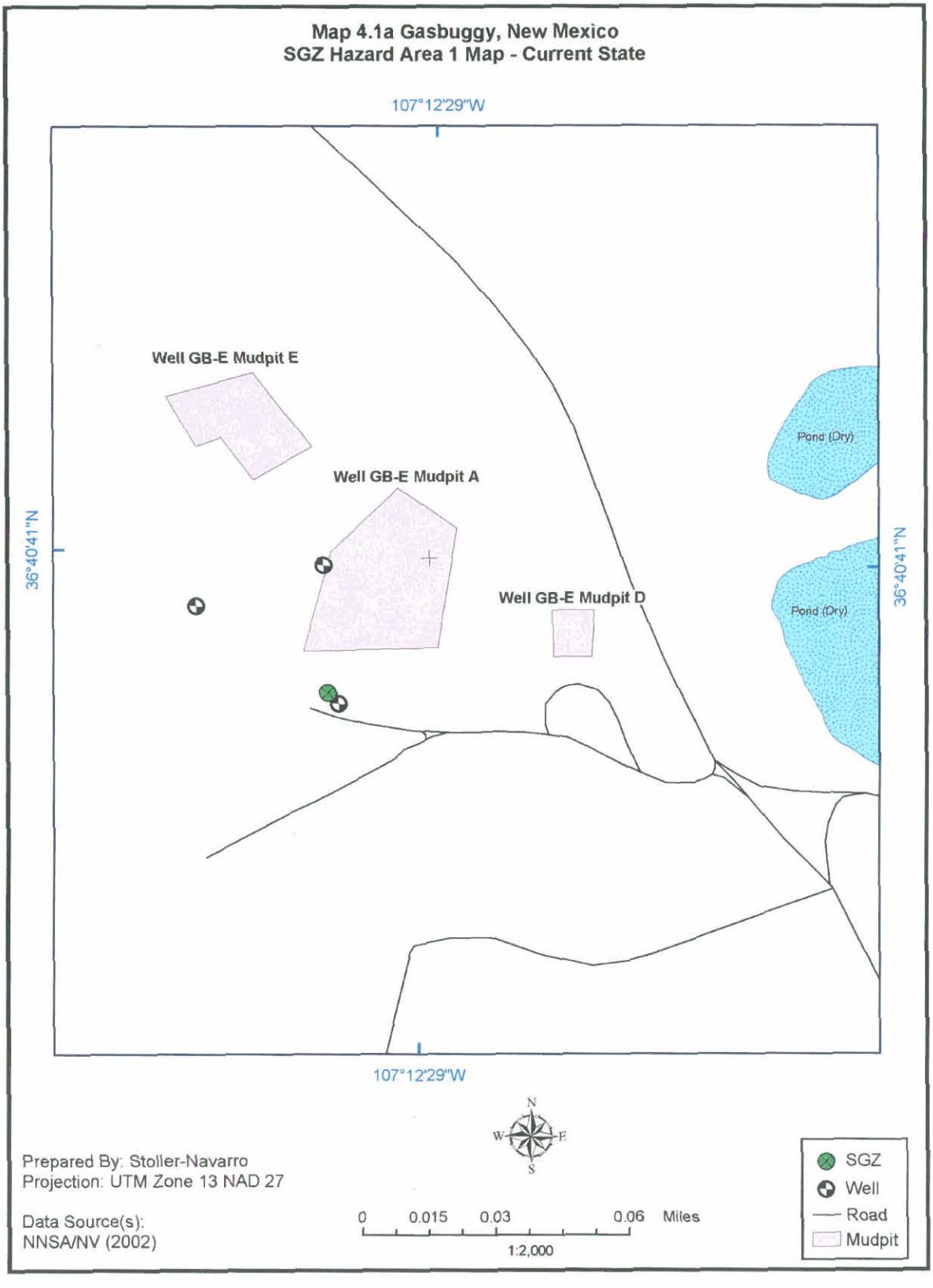
A pre-decisional draft human health risk assessment for the Gasbuggy Site prepared in June 2003 addresses the health risks to potential human receptors associated with the discovered levels of arsenic, TMB, and TPH. According to the report, the greatest lifetime cancer risk to these receptors is 9.8×10^{-7}, which is less than the EPA target range of 1×10^{-6} to 1×10^{-4} (EPA, 1991). The greatest non-cancer health hazard is 0.024, well below the EPA target of 1.00 (EPA, 1991). Based on the data provided in this draft report, the concentrations of arsenic, TMB, and TPH at the two locations on the Gasbuggy Site do not present a health hazard.

4.1 Surface Ground Zero Hazard Area

The SGZ area is irregularly shaped and covers approximately 8 to 10 acres. According to the *Surface Corrective Action Investigation Report with Surface Corrective Action Plan for the Gasbuggy Site, New Mexico* (NNSA/NSO, 2003), investigation work conducted at the SGZ area included two suspected septic systems, four drill pads, drilling mud pits, and drilling mud disposal trenches. Soil sample analytical results indicated that arsenic, TMB, TPH-DRO, and TPH-GRO were present above the negotiated screening action levels in one or more samples. Three mud pit locations (Well GB-E Mud Pit A, Mud Pit D, and Mud Pit E), shown on Map 4.1a, are identified as potential sources of the contaminants and will be the focus of the surface corrective action for the SGZ area (NNSA/NSO, 2003).

The arsenic results were determined to be representative of background concentrations found throughout the Gasbuggy Site; therefore, arsenic is not considered a COC. A preliminary risk assessment for TMB determined that levels found at the site are below concentrations determined to be hazardous to human health (NNSA/NSO, 2003). Although the TMB does not pose a threat to human health and the environment, it is recommended that, as a best management practice given that DOE/NSO will be performing corrective action activities at the site, soil containing TMB above Preliminary Action Levels (PALs) be removed and transported off site for disposal (NMED, 2000). Since the samples that exceeded PALs for TMB were taken from the same area that exceeded the levels for TPH, they will be removed concurrently with the TPH soil removal. Samples that contained TPH values exceeding the negotiated action level of 100 ppm were collected at the SGZ area (NMED, 2000).

Based on the results from the corrective action investigation of the Gasbuggy Site, a corrective action of clean closure is recommended following removal of surface contamination at the site. The DOE/NSO intends to clean close the site surface under the New Mexico VRP. Closure will be accomplished by removing all soil that exceeds the negotiated action levels of 100 ppm.


Map 4.1a Gasbuggy, New Mexico
SGZ Hazard Area 1 Map - Current State
107°12'29"W
36°40'41"N
Well GB-E Mudpit E
Well GB-E Mudpit A
Well GB-E Mudpit D
Pond (Dry)
Pond (Dry)
36°40'41"N
107°12'29"W
N
W
E
S
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)
0 0.015 0.03 0.06 Miles
1:2,000
SGZ
Well
Road
Mudpit

The 100-ppm level was negotiated with the New Mexico Oil Conservation District to achieve release from any further monitoring. This level of clean closure under the VRP will provide unrestricted release of the surface area with no further surface restrictions or institutional controls. The DOE/NSO anticipates completing all surface closure remediation activities at the site during FY 2004 (DOE/EM, 2001). Current land use designations (recreational and grazing) and subsurface intrusion restrictions will continue into the foreseeable future, and it is anticipated that they will be the end state (Map 4.1b).

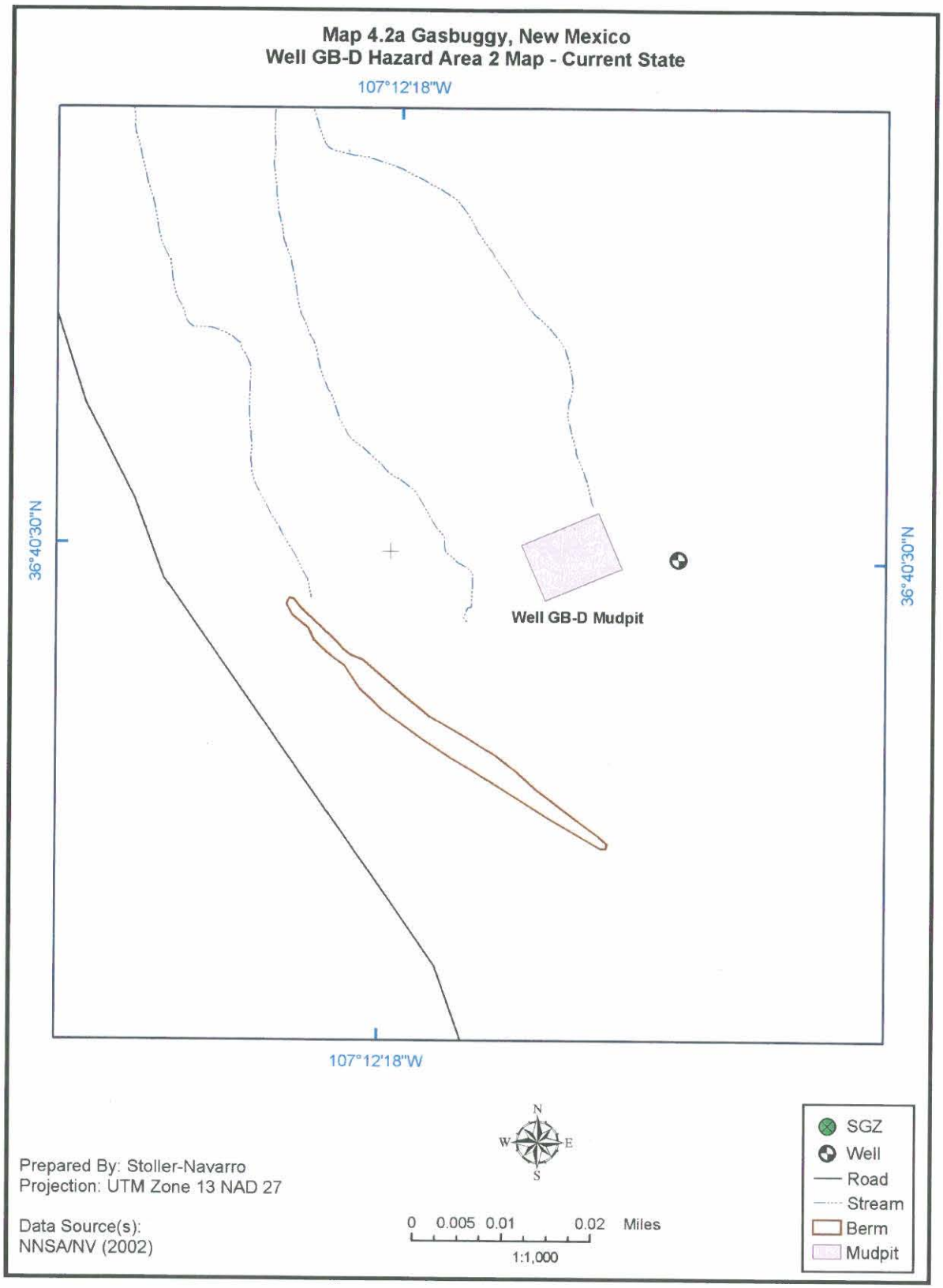
Three boreholes were completed during the 2002 investigation, at depths of 45, 56, and 74 ft bgs in the SGZ area. Static groundwater was not identified in any of these boreholes. The deepest contamination identified in the SGZ area was at approximately 16 ft bgs. There is no static groundwater within 30 vertical feet of contamination in the SGZ area. Shallow groundwater is not considered an exposure pathway at the SGZ area (NNSA/NSO, 2003).

4.2 Well GB-D Hazard Area

The Well GB-D area is approximately 1,500 ft southeast of Well GB-E, which is located in the SGZ area. The location includes Well GB-D and associated facilities in an area approximately two to three acres in size. Well GB-D was used for the placement of instruments to measure ground motion during the Gasbuggy test. Possible sources of contamination at this location included a single mud pit and potential releases from the drill pad. According to historical documentation, no post-detonation activities (e.g., drilling or gas production) were carried out at this location (AEC, 1971). Well GB-D was plugged and abandoned during the 1978 restoration. Upon completion of all other restoration activities, the area around Well GB-D was reshaped, graded, and seeded (DOE/NV, 1983).

According to the *Surface Corrective Action Investigation Report with Surface Corrective Action Plan for the Project Gasbuggy Site, New Mexico* (NNSA/NSO, 2003), diesel and arsenic were identified above PALs in site characterization samples in the Well GB-D Mud Pit (Map 4.2a). Samples collected in this area exceeded the PAL of 100 milligrams per kilogram for TPH (NNSA/NSO, 2003). The arsenic results were determined to be representative of background concentrations found throughout the Gasbuggy Site; therefore, it was determined that they pose no increased risk to human health or the environment.


Map 4.1b Gasbuggy, New Mexico
SGZ Hazard Area 1 Map - End State
107°12'29"W
36°40'41"N
Pond (Dry)
Pond (Dry)
36°40'41"N
107°12'29"W
N
W
E
S
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)
0 0.015 0.03 0.06 Miles
1:2,000
SGZ
Well
Road
Berm


Map 4.2a Gasbuggy, New Mexico
Well GB-D Hazard Area 2 Map - Current State
107°12'18"W
36°40'30"N
Well GB-D Mudpit
107°12'18"W
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)
N
W
E
S
0 0.005 0.01 0.02 Miles
1:1,000
SGZ
Well
Road
Stream
Berm
Mudpit

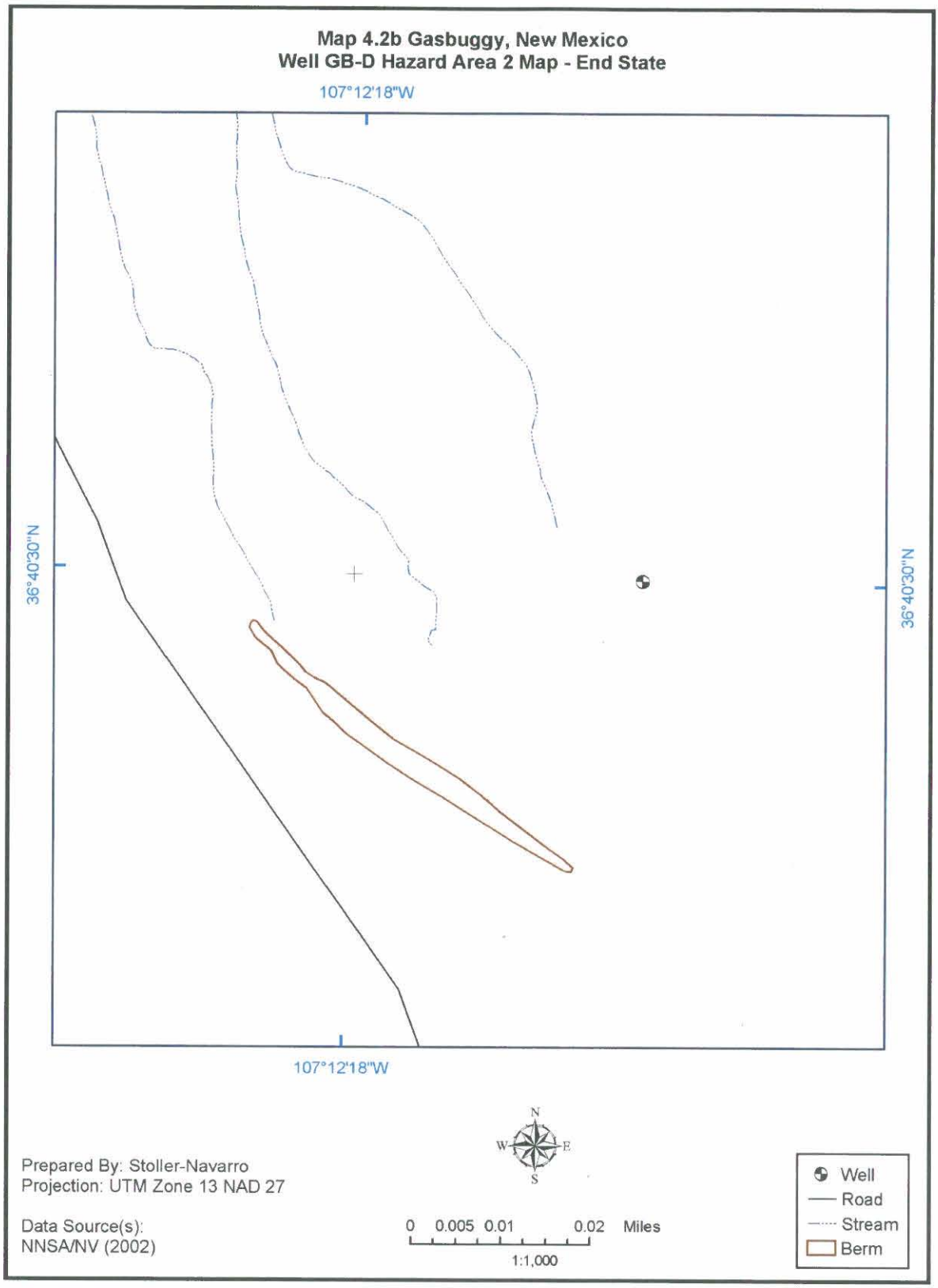
Based on the results from this investigation, a corrective action of clean closure has been recommended for the end state, following removal of surface contamination at the site (Map 4.2b). The DOE/NSO intends to clean close the site surface under the New Mexico VRP. Closure will be accomplished by removing soil from the mud pit. The DOE/NSO anticipates completing all surface closure activities at the site in FY 2004 (DOE/EM, 2001).

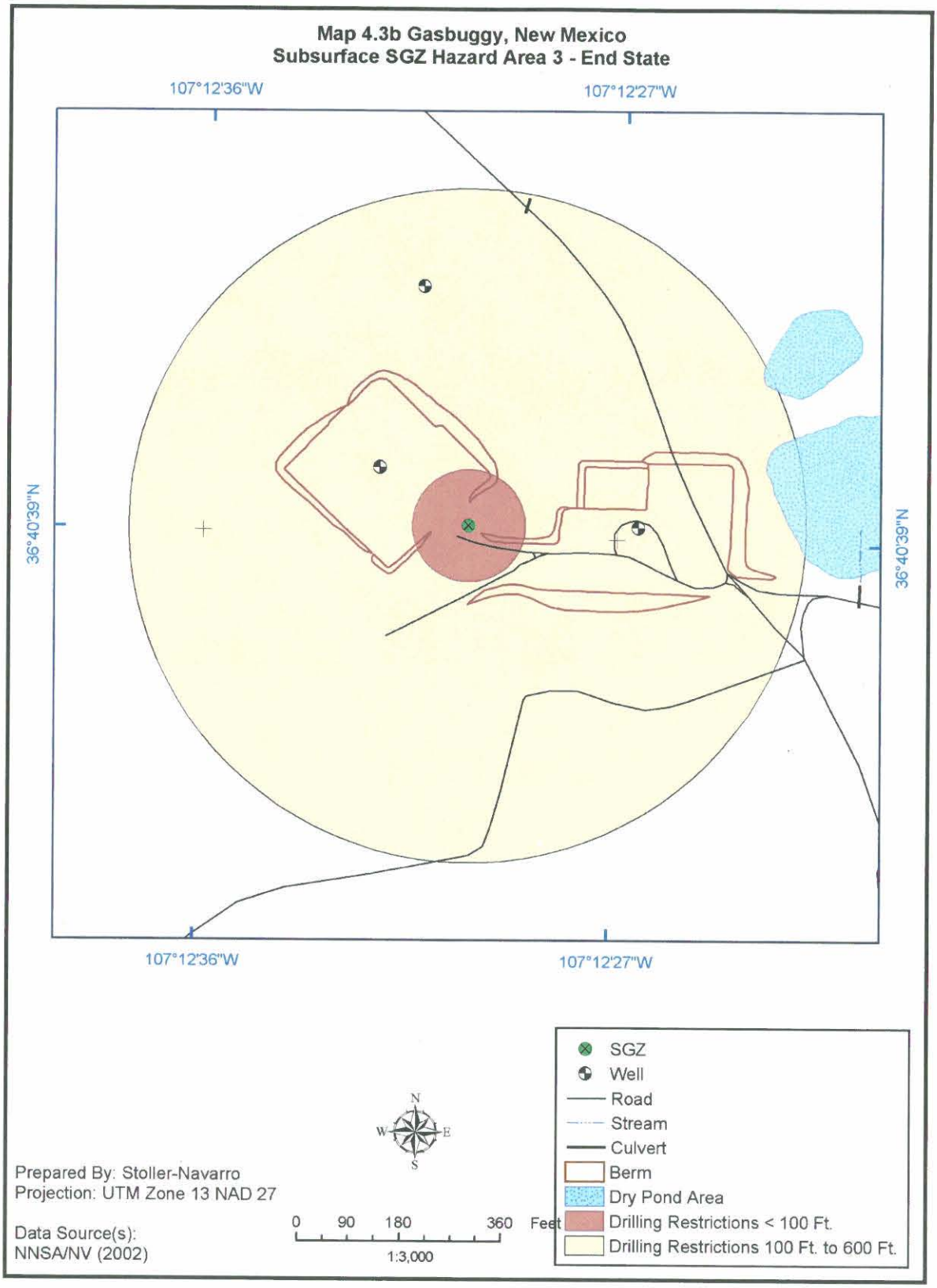
Three shallow groundwater boreholes were completed at the Well GB-D area, at depths of 58, 58, and 75 ft bgs, respectively. Static groundwater was identified at approximately 52, 57, and 58 ft bgs in the boreholes. No COCs other than arsenic were identified above PALs in soil samples. The arsenic concentrations were determined to be representative of site background conditions. Shallow groundwater is not considered an exposure pathway at the Well GB-D area (NNSA/NSO, 2003).

4.3 Subsurface Hazard Area

No subsurface characterization has been performed yet at this site; however, the DOE/NSO will continue to investigate and model subsurface contamination. Based on the historic use of the site and characterizations conducted at similar sites, plutonium, uranium, tritium, and mixed fission products are expected to be present in the subsurface, with the gaseous radionuclides (tritium, carbon-14, and krypton-85) being the most mobile in the environment. The DOE/NSO does not plan to remediate subsurface contamination due to the lack of feasible technologies; therefore, the current state is the end state for the subsurface at the Gasbuggy Site (Map 4.3b). According to the Life-Cycle Baseline Revision 5, subsurface closure of the Gasbuggy Site is expected to be completed in FY 2014 (DOE/EM, 2001).

Current land use designations (grazing and recreational) and subsurface intrusion restrictions will continue into the foreseeable future; however, the DOE has not fully characterized the contamination and long-term stewardship activities have not yet been finalized. The DOE/NSO will maintain institutional controls over the subsurface in perpetuity to prevent access to the test cavity, groundwater, and associated subsurface contamination (DOE/EM, 2001).


Map 4.2b Gasbuggy, New Mexico
Well GB-D Hazard Area 2 Map - End State
107°12'18"W
36°40'30"N
36°40'30"N
107°12'18"W
N
W
E
S
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)
0 0.005 0.01 0.02 Miles
1:1,000
Well
Road
Stream
Berm


Map 4.3b Gasbuggy, New Mexico
Subsurface SGZ Hazard Area 3 - End State
107°12'36"W
107°12'27"W
36°40'39"N
SGZ
Well
Road
Stream
Culvert
Berm
Dry Pond Area
Drilling Restrictions < 100 Ft.
Drilling Restrictions 100 Ft. to 600 Ft.
N
W
E
S
0 90 180 360 Feet
1:3,000
Prepared By: Stoller-Navarro
Projection: UTM Zone 13 NAD 27
Data Source(s):
NNSA/NV (2002)

5.0 References

AEC, see U.S. Atomic Energy Commission.

Chapman, J., T. Mihvec, and B. Lyles. 1996. *Tritium Migration at the Gasbuggy Site: Evaluation of Possible Hydrologic Pathways*, DOE/NV/11508--12, Publication No. 45144. Las Vegas, NV: Desert Research Institute.

Cooper, C.A., and J. Chapman. 2001. *Modeling Approach for Evaluating Radionuclide Transport in Nuclear-Stimulated Gas Reservoirs*, DOE/NV/13609--15, Publication No. 45186. Las Vegas, NV: Desert Research Institute.

DOE, see U.S. Department of Energy.

DOE/EM, see U.S. Department of Energy, Office of Environmental Management.

DOE/NV, see U.S. Department of Energy, Nevada Operations Office.

Earman, S., J. Chapman and R. Andricevic. 1996. *Assessment of Hydrologic Transport of Radionuclides from the Gasbuggy Underground Nuclear Test Site, New Mexico*, DOE/NV/11508--16, Publication No. 45148. Las Vegas, NV: Desert Research Institute.

EPA, see U.S. Environmental Protection Agency.

Federal Register. 1967. Public Land Order 4232, "New Mexico Withdrawal for Underground Atomic Energy Experiment," Vol. 32, No. 124. 28 June. Washington, DC: U.S. Government Printing Office.

Holzer, A. 1970. "Gasbuggy in Perspective." In *Proceedings of the American Nuclear Society Symposium of Engineering with Nuclear Explosives*, Vol. 1, CONF-700101. American Nuclear Society. Washington, DC.

Johnston, J. (Stoller-Navarro Joint Venture). 2003a. Personal communication to T. Santor (Stoller-Navarro Joint Venture) regarding the land status of Offsites locations, 7 October. Las Vegas, NV.

Johnston, J. (Stoller-Navarro Joint Venture). 2003b. Personal communication to T. Santor (Stoller-Navarro Joint Venture) regarding the land use plans and ownership of Offsites locations, 7 October. Las Vegas, NV.

Lyles, B., J. Chapman, and D. Gillespie. 2003. *Investigations in Well EPNG 10-36 at the Gasbuggy Nuclear Test Site, Rio Arriba County, New Mexico*, DOE/NV/13609--31, Publication No. 45202. Las Vegas, NV: Desert Research Institute.

New Mexico Environment Department. 2000. *Use of Total Petroleum Hydrocarbon (TPH) Test Results for Site Characterization,* Position Paper. Santa Fe, NM: Hazardous Waste Bureau.

NMED, see New Mexico Environment Department.

NNSA/NSO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

NNSA/NV, see U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office.

Smith, D.K. 2001. *Unclassified Radiological Source Term for the Nevada Test Site Areas 19 and 20*, UCRL-ID-141706. Livermore, CA: Lawrence Livermore National Laboratory.

Stahl, D. (Shaw Environmental, Inc.) 2003. Letter to M. Sanchez (U.S. Department of Energy, Environmental Restoration Division), entitled "Transmittal of the Letter of Accomplishment for the Plugging and Abandonment of the Gasbuggy EPNG #10-36 Well in Fiscal Year (FY 2003)," 30 September. Las Vegas, NV.

Taft, R.W. (U.S. Department of Energy, Nevada Operations Office). 1978. Correspondence to D. N. Canfield (El Paso Natural Gas Company) regarding Project Gasbuggy, Well No. 10-36, Purchase Order, 27 September. Las Vegas, NV.

TRC. 2000a. *Biological Assessment and Evaluation, Gasbuggy Site, Carson National Forest, Rio Arriba County, New Mexico*. Albuquerque, NM.

TRC. 2000b. *Cultural Resource Survey Report of Four Operational Areas for the Gasbuggy Site, Carson National Forest, Rio Arriba County, New Mexico*. Albuquerque, NM.

U.S. Atomic Energy Commission. 1971. *Project Gasbuggy Manager's Report*, PNE-G-79, NVO-37. Las Vegas, NV.

U.S. Census Bureau. 2000. *Your Gateway to Census 2000, State and County Quick Facts*, Census 2000 Homepage as accessed at http://www.census.gov/main/www/cen2000.html on October 2, 2003.

U.S. Department of Energy. 2003. DOE Policy No. 455.1, "Use of Risk-Based End States." Washington, DC: U.S. Government Printing Office.

U.S. Department of Energy, National Nuclear Security Administration, Nevada Operations Office. 2002. *Site Characterization Work Plan for Gasbuggy, New Mexico*, Rev. 1, DOE/NV--690-Rev. 1. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2003. *Surface Corrective Action Investigation Report with Surface Corrective Action Plan for the Gasbuggy Site, New Mexico,* DOE/NV--908. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1983. *Project Gasbuggy Site Restoration Final Report*, PNE-G-90, NVO-211. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1988. *CERCLA Preliminary Assessment of DOE's Nevada Operations Office Nuclear Weapons Testing Areas*. In publication. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1993. *Floodplains and Wetlands Survey Results for the Gasbuggy and Gnome-Coach Sites, New Mexico*, DOE/NV/10972--58. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2000. *Human Health and Safety Risk Summary Offsites Test Areas*. In publication. Las Vegas, NV.

U.S. Department of Energy, Office of Environmental Management. 2001. *A Report to Congress on Long-Term Stewardship, Volume II - Site Summaries*, DOE/EM--563. Washington, DC.

U.S. Department of Energy, Office of Environmental Management. 2003. *Guidance for Developing a Site-Specific Risk-Based End State Vision*. Washington, DC.

U.S. Environmental Protection Agency. 1991. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions*, OSWER Directive 9355.0-30. Washington, DC: Office of Solid Waste and Emergency Response.

U.S. Environmental Protection Agency. 2001. *Improving Sampling, Analysis, and Data Management for Site Investigation and Cleanup*, EPA-542-F-01-030a. Washington, DC: Office of Solid Waste and Emergency Response.

USGS, see U.S. Geological Survey.

U.S. Geological Survey. 2001. *Federal Land Features of the United States – Parkways and Scenic Rivers*. Reston, VA.

Wycoff, R.C. (U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office). 2003. Letter to W. Price (State of New Mexico Energy, Minerals and Natural Resources Department, Oil Conservation Division, Environmental Bureau) entitled, "Gasbuggy EPNG 10-36 Well Logs and Correspondence," 2 July. Las Vegas, NV.

Attachment A – Discussion of Variances

The following variance report table is provided in accordance with Appendix D of the Environmental Management End State Vision Development Guidance dated September 11, 2003. The table below does not identify any variances, but does provide information clarifying why there are no perceived differences between the various plans and agreements governing activities at the site. There are no negative impacts in terms of scope, cost, schedule, and risk, and no known barriers to achieving the end state. Based on the above noted belief, the next steps are identified for future activities associated with the Gasbuggy Site. There are no maps provided, as there are no differences between the end state based on the current requirements and the end state based on the end state vision. The maps within the main body of the end state document sufficiently identify pertinent information related to the Gasbuggy Site.

Gasbuggy Site Variance Report				
ID No.	**Description of Variances**	**Impacts (in Terms of Scope, Cost, Schedule, and Risk)**	**Barriers in Achieving the End State**	**Recommendations**
N/A	There are no known variances between the end state, the current Offsites baseline, the DOE/NSO Performance Management Plan, and/or regulatory agreements. The current baseline plans include funds to clean up TPH-DRO to a level of 100 ppm, as agreed to by State regulators.	Because no change is being proposed, there are no impacts. The clean-up effort is already in the baseline. DOE has made agreements with the New Mexico Environment Department and Oil Conservation Division that require cleanup to a level of 100 ppm for TPH-DRO. Remediation to this level will release the surface area from any further monitoring.	None. Cleanup to the planned level exceeds the risk-based end state requirements.	Proceed with the clean-up effort as provided for in the baseline. Support completion of future subsurface plans and documents and prepare the necessary long-term stewardship information for transfer of the management responsibility of the site subsurface to the Office of Legacy Management.